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WATER SUPPLY AND WATER QUALITY CONTROL STUDY BIRCH RESERVOIR, ELK RIVER BASIN (TRIBUTARY TO KANAWHA RIVER), WEST VIRGINIA

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
CHARLOTTESVILLE, VIRGINIA

MARCH 1966

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WATER SUPPLY AND
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BIRCH RESERVOIR
ELK RIVER BASIN
(TRIBUTARY TO KANAWHA RIVER)
WEST VIRGINIA

STUDY OF POTENTIAL NEEDS AND VALUE OF WATER FOR MUNICIPAL, INDUSTRIAL AND QUALITY CONTROL PURPOSES

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U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
REGION III
CHARLOTTESVILLE, VIRGINIA
March, 1966

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16. Abstracts

Municipal and industrial water supply needs, future water supply storage requirements, and streamflow regulation for water quality control are determined for the Birch River Basin, Elk River from Sutton Dam to its mouth at Charleston, and the Kanawha River from Kanawha Falls to its confluence with the Ohio River. Project needs and benefits were evaluated on a 60-year basis from 1960 to 2020, based on projected population and industrial growth.

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WATER SUPPLY AND
WATER QUALITY CONTROL STUDY
BIRCH RESERVOIR
ELK RIVER BASIN
WEST VIRGINIA

ABSTRACT

A Survey has been made which discloses an immediate need for storage for streamflow regulation for the purpose of water quality control. This conclusion is based on results of economic and demographic studies. Future needs are based on projected population and industrial growth.

Prepared at the request of the District Engineer,
U. S. Department of the Army, U. S. Army Engineer
District - Huntington, West Virginia.

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Federal Water Pollution Control Administration
Ohio River Basin Project
Wheeling Field Station, West Virginia

March 1966

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*Water Quality Control - Kanawha River

I. INTRODUCTION

Request and Authority

This study was initiated at the request of the District Engineer, U. S. Army Engineer District, Huntington, West Virginia, at the First Meeting of the Coordinating Committee for the Kanawha Basin Comprehensive Study, July 28-29, 1964. The cooperation of the Public Health Service[1] was requested in determining water needs and benefits which could be provided by a reservoir on the Birch River in Braxton County, West Virginia.

Authority to conduct this study is provided in the Federal Water Pollution Control Act (Public Law 84-660, as amended by Public Law 87-88 and Public Law 89-234) and in a Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education and Welfare, implementing the Water Supply Act of 1958 (Title III of Public Law 85-500, as amended by Public Law 87-88).

Purpose and Scope

The purpose of this study is to determine present municipal and industrial water supply needs, the need for and value of storage for future municipal and industrial water supply, and for the regulation of streamflow for the purpose of water quality control in the study area. The study area covers the Birch River Basin, the Elk River from Sutton Dam to its mouth at Charleston, and the Kanawha River from Kanawha Falls to its confluence with the Ohio River. The study area includes all of Clay, Kanawha and Boone Counties, and portions of Braxton, Nicholas, Webster, Mason, Putnam, Jackson, Roane and Fayette Counties.

[1] Water pollution control activities are now the responsibility of the Federal Water Pollution Control Administration.

Project needs and benefits have been evaluated on a 60-year basis from 1960 to 2020.

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West Virginia Department of Health.
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U. S. Department of Commerce, Bureau of Census.
West Virginia Department of Commerce.
Communities of Charleston, South Charleston, Nitro, St. Albans, and Dunbar, West Virginia.
West Virginia Water Company.
Appalachian Power Company.
Ohio River Valley Water Sanitation Commission.

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The proposed multiple-purpose Birch Reservoir would be located at the mouth of the Birch River near Frametown in Braxton County, West Virginia. This project would be developed by the U. S. Army Corps of Engineers.
2. The average annual discharge of the Birch River, based on a 33-year period of record (1929-1963), is 335 cubic feet per second (cfs). The maximum discharge was approximately 9,250 cfs, occurring on February 3, 1939. The minimum was 0.5 cfs, occurring on October 27, 1953.
3. The Birch River Basin covers 142 square miles in central West Virginia. It is tributary to the Elk River, which flows southwestward to join the Kanawha River at Charleston. The study area lies principally in Braxton, Clay, Fayette, Kanawha, Putnam and Mason Counties, West Virginia.
4. The population of the study area is approximately 367,000. About 170,000 reside in the urbanized Charleston area. More than half of the study area population is classified as urban.
5. Generally, the waters of the Birch and Elk Rivers present no water quality problems, and reflect the low population density and limited water use in these two basins.
6. The Elk River is presently the primary source of municipal water for the Charleston area.

7. Except for the water supplied to industry by municipal water facilities, industrial use of Elk River water is limited.

8. The area along the lower Kanawha River is highly industrialized. The greatest use of the Kanawha River for municipal and industrial water supply and for waste disposal occurs in the vicinity of Charleston. Water navigation and the close proximity to vast coal, oil, gas and salt reserves have been major factors in this development.

9. Present municipal waste loading to the Kanawha River in the urbanized Charleston area, after primary treatment (35% First Stage BOD Removal), amounts to about 117,000 population equivalents. The major industries, predominately chemical, contribute an estimated 1,260,000 population equivalents of oxidizable organic wastes to the river after removal of approximately 40 percent of the initial first stage load.

In addition, there exists a second stage waste load being discharged by these industries which is notable. It has a decisive effect on the water quality of the Kanawha River. In comparison, this second stage waste load has an oxygen demand nearly one and a half times as great as the total carbonaceous first stage waste load discharged in the Charleston area.

10. Domestic water supplied by surface sources in the study area amounts to more than 26 million gallons per day (mgd), and serves an estimated 200,000 persons (average 130 gallons per capita per day). Industrial water use approaches 1,140

million gallons per day, of which, about 97 percent is for cooling purposes.

11. As a result of excessive municipal and industrial discharges, water quality of the Kanawha River is seriously degraded downstream from Charleston with the dissolved oxygen being completely exhausted for several weeks at a time during extreme low flow periods. Industrial wastes add tastes and odors to the water which render the river unsuitable for domestic water supplies downstream, even after conventional treatment.

Conclusions

1. The population of the study area is expected to increase from 367,000 as of 1960, to 394,700 by year 2000 and to 448,800 by year 2020. Most of this increase will occur in and near the urbanized Charleston area.
2. The present plan of the West Virginia Water Company is to construct a new plant in Charleston which would supply the combined needs of the existing Charleston, Nitro, and Belle Water Systems using the Elk River and an intake on the Kanawha River near Belle, West Virginia.
3. Based upon projected productivity and employment, industrial use of Kanawha River water is expected to increase from about 1,140 mgd including cooling water use to nearly 3,912 mgd by the year 2020.

4. Since the Kanawha River is almost entirely canalized, water is available to meet present and future industrial water supply needs, except as reuse of the stream may be limited due to excessive quality degradation. Thus, no storage is needed in the proposed Birch Reservoir to meet anticipated needs for industrial purposes along the Kanawha River through the next 60 years.

5. The reach of the Kanawha River in the vicinity of Charleston is expected to continue to receive the greatest waste load of the entire stream system within the study area. The area downstream from Charleston is expected to receive progressively higher waste loads in the future due to anticipated industrial growth in the lower reaches of the Kanawha. Even with the provision of adequate treatment of municipal wastes and with adequate treatment or equivalent control of industrial wastes, monthly flows of as high as 7,800 cfs would be required to assimilate anticipated organic waste loads by year 2000, if the present West Virginia State goal of 3 mg/1 of dissolved oxygen is maintained at the sag point. This exceeds the present dependable flow of the Kanawha River below Charleston by 5,870 cfs. Since this goal is believed to be too low for nine out of every ten years in light of present water quality emphasis, it has been computed that by the year 2000 a maximum monthly flow of 10,200 cfs will be needed to maintain a minimum of 4 mg/1 of dissolved oxygen at its lowest point in the river. To maintain a minimum of 5 mg/1 of dissolved oxygen would require 15,000 cfs by the year 2000. A minimum dissolved oxygen level in the Kanawha of 4 mg/1 would provide about 5.5 mg/1 at the mouth, and a minimum of 5 mg/1 would provide about 6 mg/1 of

dissolved oxygen at the mouth. Of the three objectives, 5 mg/l of the dissolved oxygen at the sag point is the most desirable, however this would require so much additional flow as to be unrealistic. A more realistic goal of 4 mg/l of dissolved oxygen at the sag point has therefore been established.

6. Storage requirements for the year 2000 to meet minimum dissolved oxygen requirements of 3, 4 and 5 mg/l at the critical point are as follows:

Dissolved Oxygen, mg/l	Annual Draft-on-Storage* Acre-Feet
3	1,400,000
4	1,949,000
5	3,651,000

The year 2000 was selected because the draft-on-storage requirement for 2020 would burden the available water resources of the basin. The storage requirement needs are based on economic projections of both population and industrial growth which are believed to be reasonable for the year 2000.

---

*Annual draft-on-storage is the sum of incremental excesses of needed releases over inflows during a climatic year at Charleston, West Virginia, and does not include storage and transmission losses.

Based on an anticipated possible reliable storage capacity in the Birch Reservoir of 55,900 acre-feet for quality control water, the following range of storage volumes in acre-feet and related value of benefits is given:

Annual Draft-on-storage (Acre-feet)	Average Annual Benefits Dollars
20,000	322,500
40,000	381,500
60,000	446,500
80,000	510,500

The average annual benefit of a draft-on-storage of 55,900 acre-feet is therefore about $416,000.

7. Regulation of streamflow by the Birch Reservoir will provide increased assured flows in the Elk, Kanawha, and Ohio Rivers, improve dissolved oxygen concentrations, reduce stream temperatures, and result in an overall quality improvement.

8. The quality of the discharged water may be reduced as a result of thermal stratification, density underflow, or other conditions. Multiple-level outlets, together with information on water quality at several depths would make possible the flexibility in management necessary to maintain acceptable dissolved oxygen levels and uniform temperatures in reservoir discharges. Provision should be made in the design of the Birch Dam for multiple-level outlets and access for water quality monitoring equipment. Downstream monitoring sites should also be utilized as well as data from the United States Weather Bureau's streamflow forecasting unit.

9. The monetary value of storage benefits for industrial water supply was not determined. No need for such storage exists in the Elk River downstream from the proposed reservoir.

10. The storage needs and benefits provided in this report are subject to review and revision based upon comprehensive studies of the Ohio River Basin currently under way. However, they may be used for project evaluation at this time. Benefits are based on the cost of the most likely alternate that would be used in the absence of the proposed project.

11. While the benefits discussed apply primarily to the Elk and Kanawha Rivers, widespread benefits to water quality would also be realized along the entire length of the Ohio River. Such benefits are not possible to evaluate at this time.

12. As previously indicated, there exists an immediate, as well as a future, need for storage in the proposed Birch Reservoir for water quality control. This annual benefit is $416,000.00 for the contribution to water quality control obtainable from 55,900 acre feet of storage proposed for this project. Since this storage volume is only a small fraction of the total water quality control needs in the lower Kanawha River, a network of reservoirs throughout the Kanawha Basin is under study to determine the extent to which existing and projected needs can be fulfilled.

III. PROJECT DESCRIPTION

Location

The Birch Reservoir Project is located on the Birch River, a tributary of the Elk River in the Kanawha River Basin, in Braxton County, West Virginia. The dam will be constructed 1.3 miles above the mouth of the Birch River. It is about 48 miles northeast of Charleston and 60 miles southeast of Parkersburg, West Virginia. (See Figure I, page III-2 and Figure IV at conclusion of report).

Streamflow

Hydrological data for the Birch River Basin was developed from flow records of the Elk River at Centralia, West Virginia, which has a drainage area of 281 square miles. The average computed discharge of the Birch River is approximately 335 cfs from 142 square miles of drainage area. Maximum and minimum discharge from the Birch River have been computed to be about 9,250 cfs and one-half (0.5) cfs, respectively, over the past thirty years.

Water Quality

Generally, Birch River water presents no water quality problems. It is anticipated that water stored in the proposed reservoir during periods of high runoff will be of equal or better quality than that observed during field studies in the fall of 1964. Analyses of samples collected, although representative of only one seasonal flow condition, indicate that Birch River water is of adequate quality for domestic and most industrial water supply purposes. (See

Exhibit 1 a in Appendix). These samples were collected during a low-flow period when any adverse quality conditions probably would be apparent.

Acid mine effluent is not a significant problem in the Birch River Basin.

The Birch River drains a relatively uninhabited area. The terrain of the basin, being characterized chiefly by steep to very steep slopes, is covered mostly by woods. However, much of the moderately steep to steep land is in pasture. Farming today is limited and is concentrated in the valleys and gently sloping plateau regions.

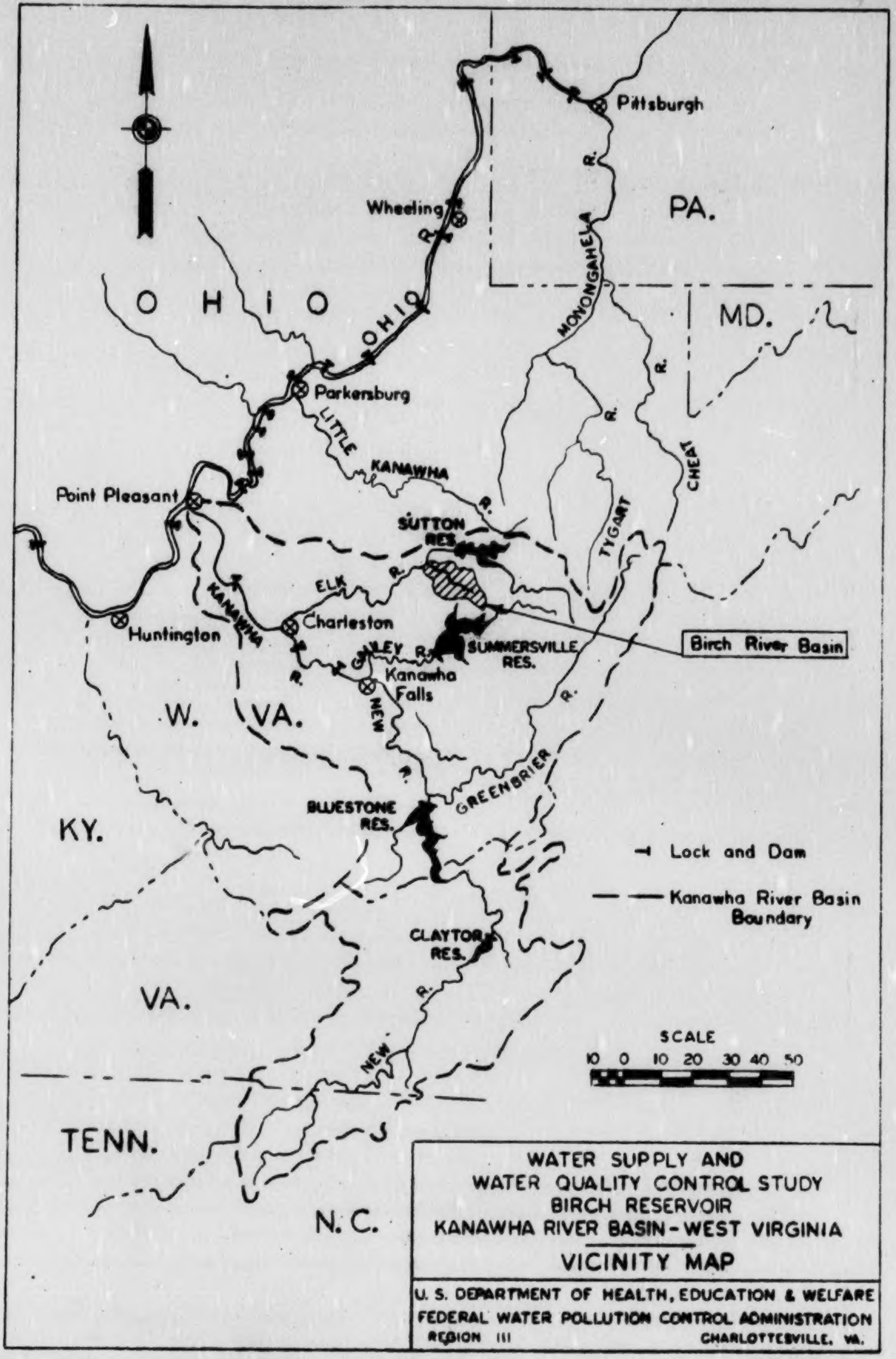
Pertinent Data

Some physical data on the proposed Birch Reservoir is presented below:

Drainage Area Controlled: 142 square miles

Reservoir:

Pool	Elevation	Capacity Acre-ft.	Capacity Inches	Area (acres)
Minimum	823	3,700	0.5	200
Water Quality Control (Winter)	925	55,900	7.4	940
Water Quality Control (Seasonal)	937	67,900	9.0	1,050
Flood Control (Seasonal)	965	34,200	4.5	1,420
Flood Control (Winter)	965	46,200	6.1	1,420
TOTAL STORAGE:	965	105,800	14.0	1,420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Charleston
Huntington
Birch River Basin
GAULEY R.
SUMMERSVILLE RES.
Kanawha Falls
NEW R.
W. VA.
R.
GREENBRIER
BLUESTONE RES.
KY.
Lock and Dam
Kanawha River Basin Boundary
CLAYTOR RES.
R.
VA.
NEW
SCALE
10 0 10 20 30 40 50
TENN.
N.C.

WATER SUPPLY AND
WATER QUALITY CONTROL STUDY
BIRCH RESERVOIR
KANAWHA RIVER BASIN - WEST VIRGINIA

VICINITY MAP

U. S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
REGION III CHARLOTTESVILLE, VA.

FIGURE I

IV. STUDY AREA DESCRIPTION

Location and Boundaries

The study area includes all of the Birch River drainage area, the Elk River from Sutton Dam (see Figure I) to its mouth at Charleston, and the Kanawha River from Kanawha Falls through Charleston to its confluence with the Ohio River at Point Pleasant.

The Birch River basin lies in portions of Braxton, Nicholas, and Webster Counties, a mountainous, sparsely-settled area in central West Virginia. State highway No. 4, along the Elk River, and U. S. highway No. 19, which bisects the basin north-south, offer the only access to the drainage area and its few small communities.

The Elk River basin lies within the Kanawha River watershed, which is located in the southeastern portion of the Ohio River basin. The Elk River basin is wholly within the state of West Virginia and includes portions of eight counties. The upper areas of the basin are bounded by the Little Kanawha, Tygart, Cheat, Greenbrier and Gauley River watersheds, all of which rise in the same general mountainous area as the Elk River. The lower basin areas are bounded by the Pocatalico River watershed to the northwest and minor watersheds of the Kanawha River to the southeast. The total drainage area of the Elk River basin is 1,536 square miles, 537 square miles of which are above Sutton Dam.

The Kanawha River is formed by the New and Gauley Rivers at Kanawha Falls, West Virginia and thence flows 97 miles northwestward to its confluence with the Ohio River. The Kanawha River passes through an area of heavy industrialization from mile point 42 to mile point 70, the concentration of which progressively increases toward Charleston. (See Figure IV). The industries within this 28 mile stream reach are involved chiefly in the manufacture of chemicals and allied products. The river is used extensively for navigation and is canalized for that purpose.

Geography and Topography

The study area lies wholly within the unglaciated portion of the Appalachian Plateaus. The basin has been highly dissected by erosion into a region marked by a succession of nearly level-topped ridges and hills separated by deep, sinuous, narrow V-shaped valleys. The surface rocks of the basin are of Pennsylvania series and consist principally of sandstone and shale with numerous beds of coal and clay and a few limestone strata. The valley bottoms contain river deposited sediment consisting of silt, clay, sand, and gravel. Soil cover on some of the steep valley hillsides is shallow, as indicated by numerous rock outcroppings. Generally, relief in the headwater areas is about 1,000 feet. In the lower portions of the basin, relief is generally about 500 feet.

Climate

The climate of the Elk River is typical of many regions of the north temperate zone. Topographic characteristics of the basin considerably modify the latitudinal control of the climate, with the result that marked variations in temperature and precipitation occur between mountain and plateau areas. The seasons are nearly of equal length and are strongly contrasted. Winters are moderate to rigorous and only occasionally severe. The summers are warm in the low valleys and rather mild in the mountains, where temperatures in excess of 90 degrees occur infrequently. The mean annual temperature of the study area is 56°F. Precipitation is ample (49 inches) and well distributed throughout the year. On the average, somewhat more than half of the year's precipitation falls during the warm season, April to September. Summer rainfall occurs mostly during thunderstorms or as moderate showers in connection with low pressure areas that pass north of the basin. The heaviest precipitation of late fall and winter months occurs during passage of general storms that move from the southwest in a northeastward direction over the Ohio Valley. Occasionally, decadent tropical hurricanes moving northward parallel to the Atlantic coast will cross the Appalachian Range and deposit enough rain to cause heavy flooding.

Principal Communities and Industries

The present population of the study area is approximately 330,000 and is dominated by the Charleston metropolitan area which comprises about half of the total population.

Principal urban places and their respective populations (1960 census) are as follows:

COMMUNITY	1960 POPULATION	COMMUNITY	1960 POPULATION
Charleston	85,796	Marmet	2,500
South Charleston	19,180	Cedar Grove	1,569
Saint Albans	15,103	Clendenin	1,510
Dunbar	11,006	Gassaway	1,223
Nitro	6,894	Institute	1,040
Point Pleasant	5,785	East Bank	1,023
Montgomery	3,000	Sutton	967
Chesapeake	2,699	Glasgow	914
Belle	2,559	Clay	486
		Winfield	318

Charleston, the State Capital, is one of the most important industrial centers in the country. The bulk of the industries are located in Kanawha County, along the Kanawha River, in the 28-mile stream reach from mile point 42 to mile point 70. (See Figure IV). The chemical industry, in particular, has enjoyed steadfast growth due to the abundance of water and fuel and the availability of raw materials in Kanawha County and adjacent counties.

Coal mining is extensive throughout the study area. Other industries include the manufacture of glass, steel products, paint, petroleum products, and synthetic rubber. Numerous natural gas and oil wells are located in the study area with continuous exploration and drilling of new wells being carried on.

Two large steam-generating plants producing electrical power are located on the Kanawha River in Kanawha County, thus taking advantage of the abundant coal supply and available cooling water. Furthermore, hydroelectric power plants are an integral part of each of the three navigation dams on the Kanawha River.

In addition to coal, gas, and oil, other mineral resources of the study area include natural brines, fire clay, sand, and sandstone.

Because of the mountainous terrain, agriculture is limited. Less than ten percent of the land is used for crops and fifteen percent is in pastures. Three-quarters of the land in the basin is forested.

V. WATER RESOURCES OF THE STUDY AREA

Quantity of Water Available

The base period used in this analysis for projections of future water use and development was the year 1960. The latest available U. S. Geological Survey stream flow records used in this report are for Water-Year 1962-63. Various hydrologic data prepared by the U. S. Army Corps of Engineers was received in 1964. A stream water-quality survey was conducted in the Kanawha River basin by the U. S. Public Health Service during July 1963 and again during the summer and fall of 1964.

Streamflow

For the primary purpose of flood control, three large reservoirs have been constructed in the Kanawha River basin. The operation of Sutton Reservoir on the Elk River in combination with the completed Bluestone Reservoir on the New River and the Summersville Reservoir, on the Gauley River, mainly provides relief from floods for the highly populated and industrialized Kanawha River valley. These three reservoirs will control 57 percent of the total drainage area at Charleston. Releases from flood protection reservoirs are based upon the need for maintaining an adequate flood storage capacity and are therefore not dependable for water quality control. Furthermore, flood releases generally occur during the time of the year when dependable uncontrolled runoff provides sufficient flow for proper assimilation of stream pollutants.

Of the three aforementioned reservoirs, the Sutton and the Summersville Reservoirs contain additional storage which is utilized for flow regulation during the summer and fall months.

The Elk, Kanawha and Ohio Rivers experience periods of low flow, during which times pollutants discharged into these streams become particularly significant, and the water quality of the Kanawha and Ohio Rivers becomes so poor that municipal and industrial use is impaired.

The stream reach of greatest concern in the study area is the 28 mile portion of the Kanawha River from Belle (river mile 70) to below Nitro at river mile 42. Flow in this reach is recorded at the U. S. Geological Survey gage located 3.5 miles downstream from the mouth of the Elk River. Average discharge at this point for the 24 years of record, and adjusted for storage, is 14,480 cfs. The adjustment for storage returns the recorded stream flow, as regulated by the reservoirs, to a natural stream condition. Some regulation has been provided since 1939 by Claytor Reservoir, since 1949 by Bluestone Reservoir (downstream from Claytor Reservoir), and since 1960 by Sutton Reservoir. These reservoirs have a combined usable storage capacity of 982,200 acre-feet. The maximum discharge recorded is 216,000 cfs and occurred in August 1940. During October 1953, a minimum discharge of less than 1,030 cfs was recorded. The Summersville Reservoir began operation for flood control in August 1965, with the first release coming in March 1966. Similar recorded flow data for the Kanawha River at Kanawha Falls, and for the Elk River at Queen Shoals and Frametown are shown in Table 1.

TABLE 1

STREAMFLOW CHARACTERISTICS*
Kanawha and Elk Rivers

USGS Gaging Station	River** Mile	Period of Record (Years)	Average Discharge (cfs)	Max. Disch. (cfs)	Date	Min. Disch. (cfs)	Date	Regulated by Reservoir	Since
Kanawha River @ Charleston	K 54.40	1939-1963	14,480	216,000	Aug. 1940	1,030	Oct. 1953	Claytor Bluestone Sutton	1939 1949 1960
Kanawha River @ Kanawha Falls	K 94.70	1877-1963	12,570	320,000	Sept. 1878	640	Aug. 1930	Claytor Bluestone	1939 1949
Elk River @ Queen Shoals	K 57.90 E 24.78	1928-1963	1,972	72,000	July 1932	0.3	Nov. 1953	Sutton	1960
Elk River @ Frametown (Glendon)	K 57.90 E 77.40	1958-1963	1,564	18,400	Jan. 1959	9.0	Sept. 1959	Sutton	1960

*Flows adjusted for change in reservoir content and, therefore, reflect the natural stream condition before regulation.

**K = Kanawha River
E = Elk River

Table 2 provides information concerning the various storage capacities, etc., of the Claytor, Bluestone, Sutton and Summersville Reservoirs in the Kanawha Basin. These reservoirs have a total combined capability of 1,252,100 acre-feet for flood control and 260,000 acre-feet for regulation.

Sutton Reservoir has a seasonal pool providing 60,100 acre-feet of storage to be utilized for flow regulation during the summer and fall months. Low flow releases can provide an increase of up to 400 cfs to the 7-day, once-in-10 year low-flow frequency in the Kanawha River. A minimum release of 75 cfs is assured at all times, thus assuring a minimum flow of 50 cfs in the lower reach of Elk River.

Seasonal storage in the Summersville Reservoir will be utilized during the months of April through November of each year in order to regulate low flows in the Gauley and Kanawha Rivers up to a maximum of 1000 cfs. This will increase the seven consecutive day,once-in-ten-year low flow of the lower portions of the Kanawha River to 1930 cfs (see Table 3), and will be beneficial to water supply, pollution abatement, recreation and aquatic life.

Claytor Reservoir and the smaller privately-owned reservoirs in the New River Basin are operated solely for the purpose of meeting peak power demands.

Other sources of dependable controlled flows, such as municipal and industrial water supply storage, seepage through dams, etc., are not known to be of any consequence. These flows, however, are

TABLE 2

RESERVOIRS IN KANAWHA RIVER BASIN*

Name of Reservoir Stream State	Drainage Area (sq.mi.)	Total Storage (acre-ft.)	Usable Storage (acre-ft).	Flood Control Storage, Winter (acre-ft.)	Seasonal Pool, Summer & Fall (acre-ft)	Surface Area (acres)	Storage Ratio (years)	Date Completed (year)	Use	Owner
Claytor New River Virginia	2,382	232,000	100,000	--	--	4,540	< 0.05	1939	P,R	Appalachian Electric Power Co.
Bluestone New River W. Va.	4,565	631,000	600,100	600,100	36,500	9,180	0.2	1952	F,R	Corps of Engineers
Sutton Elk River W. Va.	537	265,300	261,200	261,200	60,100	3,875		1960	F,R	Corps of Engineers
Summersville Gauley River W. Va.	803	413,800	390,800	390,800	163,400	4,920		1966	F,R	Corps of Engineers

Only those reservoirs are listed that have a usable capacity of 5,000 acre-feet or more.

P - Power FR - Flow Regulation
F - Flood Control R - Recreation

*U. S. Geological Survey Water Supply Paper 1360-A.

TABLE 3

LOW-FLOW FREQUENCIES
AS
MODIFIED BY
SUTTON AND SUMMERSVILLE RESERVOIRS*

STREAM-FLOW ANALYSIS POINTS

KANAWHA RIVER BASIN

LOCATION	7-Day 10 Year	1-Day 30 Year
Gauley River at mouth	100	100
Kanawha River below confluence Gauley and New Rivers (Kanawha Falls).	1800	1230
Kanawha River at Cedar Grove	1800	1230
Kanawha River at Charleston above mouth of Elk River.	1800	1230
Elk River at Clay	75	75
Elk River at mouth.	50	50
Kanawha River at Dunbar	1930	1320
Kanawha River at Eleanor	1930	1320
Kanawha River at mouth	1930	1320

*Reservoirs in existence or under construction with flow regulation capability.

reflected in the adjusted average discharge values shown in Table 1. The average annual 7-day low flows, with a once-in-ten year recurrence frequency, for various pertinent points in the Kanawha River Basin are shown in Table 3. This frequency is the dependability adopted in this study to determine the need for flow regulation for organic waste assimilation purposes. Below Charleston, this low-flow value had been 1,080 cfs under natural streamflow conditions. However, this value was recently increased to 1,930 cfs by the addition of the Sutton and Summersville Reservoirs.

Shown in Table 4 is the flow distribution of the Kanawha River at Charleston for the years 1939 through 1963. It can readily be seen that the lowest flows occurred most often during the month of October.

The proposed Birch Reservoir will be located 1.3 miles above the mouth of the Birch River. Hydrologic data for the Birch River Basin was developed from flow records of the Elk River at Centralia, which has a drainage area of 281 square miles. This gage is located 15 miles east of the dam site. Runoff conditions in the two drainage basins are considered similar. The drainage area at the dam-site is 142 square miles, with an average annual discharge of approximately 335 cfs. Maximum and minimum discharges observed over the 33-year period of record are approximately 9,250 cfs and 0.5 cfs, respectively. A duration curve for flow in the Birch River at the dam-site is presented in Figure II. The average monthly flows for the period of record are given in Table 5.

TABLE 4

FLOW DISTRIBUTION

KANAWHA RIVER AT CHARLESTON

1939 - 1963

Month	Number of Lowest Annual Flows	Average Adjusted Flow, cfs
January	1	19,758
February	0	25,455
March	0	30,446
April	1	23,202
May	0	16,076
June	0	9,837
July	0	8,082
August	2	7,095
September	8	4,641
October	11	4,850
November	0	8,446
December	0	15,870
Total	23	
Average:		14,480

Ground Water 1/ 2/

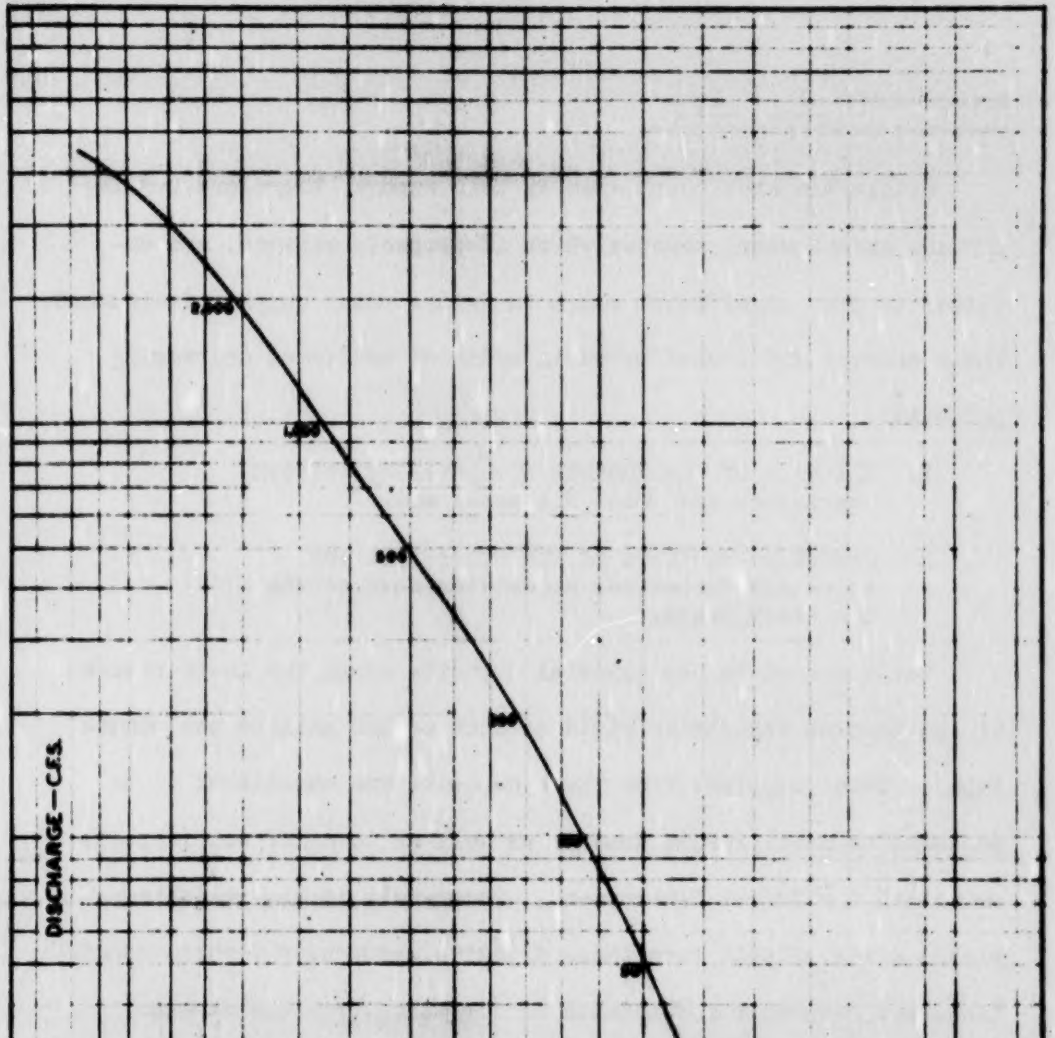
Within the area considered by this report, there are two important ground water sources which if properly managed, are expected to play significant roles in future water supply development. These sources are listed below in order of estimated decreasing potential:

1. Alluvium of the Kanawha River valley between Charleston and Point Pleasant; and,
2. Sandstone aquifers of the Pottsville and Allegheny formations underlying much of the Elk River Basin.

Wells placed in the alluvial deposits along the lower reaches of the Kanawha reportedly yield as much as 100 gallons per minute (gpm). Water supplies from these deposits are considered to be adequate to meet present demands as well as to offer considerable potential for future development. Moderately large, reliable yields are available from these deposits particularly where conditions are favorable for induced infiltration from the stream.

1/ Little Kanawha and Kanawha River Basins Including Intervening Area Draining to the Ohio River Between Parkersburg and Pt. Pleasant, Preliminary Survey of Ground-Water Distribution and Potential in the Ohio River Basin, Interim Report 3, U. S. Geological Survey, Water Resources Division, Midcontinent Area Project Office, Gahanna, Ohio, July 1964. Unpublished report.

2/ Water Resources of Kanawha County, West Virginia, West Virginia Geological and Economic Survey, Bulletin 5, 1960.



Water Resources Study
Kanawha River Basin - West Virginia
Flow Duration Curve
Birch River at Damsite
Period 1935-1968

U.S. Department of Health, Education, and Welfare
Federal Water Pollution Control Administration
Region III Charlottesville, Va.

FIGURE II

TABLE 5

FLOW DISTRIBUTION

BIRCH RIVER AT DAM SITE

Month	Number of Lowest Annual Flows	Average Flow (cfs)
January	0	503
February	0	578
March	0	674
April	0	493
May	0	358
June	1	217
July	1	218
August	2	186
September	14	73
October	15	108
November	0	238
December	0	379
TOTAL:	33	
Average:		335

The Pottsville and Allegheny aquifers which underlie the central Kanawha Basin are considered excellent and furnish most of the public ground-water in the Kanawha Basin. In Kanawha County, West Virginia, (Kanawha and lower Elk River drainage area) well yields from these formations range up to 600 gpm with an average of about 120 gpm.

In a few small communities of the Kanawha Basin, public water supplies are obtained from abandoned coal mines in the Pottsville formation. Such water is easily obtained, but it may be of poor quality.

Other Sources of Supply

The Kanawha River is navigable for 91 miles (94 percent of its length) with four locks and dams providing a 9-foot minimum navigation depth. Three of the locks and dams are located in the Kanawha River at the towns of London, Marmet, and Winfield; the fourth is located on the Ohio River, 13.5 miles downstream from the mouth of the Kanawha River, below Gallipolis, Ohio. Use of the navigation pools as a source of water continues to be an important factor in the industrial growth of the Kanawha River Valley.

In 1965, industrial plants withdrew an average of about 1,140 mgd, or 1,760 cfs, from the Kanawha River for cooling purposes.

The minimum low flow recorded during the 5-day period October 1 - 5, 1953, was less than 1,030 cfs. Recirculation of cooling water is unavoidable during periods of low flow in many years.

Quality of Water Available

Water in the Elk River drainage basin, and particularly in the Birch River Basin, generally presents no water quality problems. Exhibits 1a-e (See Appendix A) present data collected during September and October, 1964, at several points from the mouth of the Birch River downstream to near the mouth of the Elk River. Samples were collected in the Birch River during a period of low flow when the discharge would be expected to contain a substantial portion of ground water. It is evident from the data that neither the Birch River nor the Elk River are highly mineralized. Also, acid mine drainage is not considered to be a problem in the Elk River Basin. The generally low values obtained for indicators of organic and bacterial pollution reflect the sparsely-settled condition of the river basin.

Samples were collected from the Elk River near Charleston's upstream water supply intake. This intake is located out of the backwater area of the Kanawha River at mile point 4.0. The station's pumping capacity is 11,000 gallons per minute (15.8 mgd) and it is normally run continuously at full capacity. The downstream intake lies in the poor-quality backwater of the Kanawha River, and is used intermittently when pump capacity at the upper intake cannot meet the demand. Its pump capacity is 2,400 gallons per minute (3.5 mgd). The upper intake provides an average of about 85 percent of the water treated at the plant.

During the field survey, industrial wastes were observed in the lower Elk River originating from the gas and oil industries located near Clendenin. With the exception of the domestic wastes from the five major communities, these few industries comprise the only other sources of wastes being discharged to the Elk River.

Exhibit 2a-f summarizes water quality observed at six representative points along the Kanawha River during Public Health Service field studies conducted in 1963 and 1964. It should be noted that although only a few samples were collected during the most critical portion of the year (normally the month of September when low flows combine with high temperatures), both years were abnormal with extended summer drought conditions.

In July 1963, the dissolved oxygen content of the water above Winfield Dam was less than one milligram per liter during eight days of the 15-day sampling period. In this reach, the dissolved oxygen has been known to be completely exhausted for several weeks at a time during the more critical conditions. The Kanawha River is often unable to recover before it reaches its mouth near Point Pleasant; consequently, the water quality of the Ohio River is adversely affected.

A review of Exhibit 2a-f shows the progressive deterioration of water quality downstream to Winfield Dam with a slight recovery thereafter. This is particularly true of the dissolved oxygen (DO), the biochemical oxygen demand (BOD), various nitrogen compounds, and the coliform bacteria concentrations.

Considerable taste and odor-bearing substances are discharged into the Kanawha River by the chemical plants in the Charleston area. These chemicals render the river unsuitable as a source of domestic water supply. Under certain flow conditions, taste and odor ascribed to these wastes have been noted in the water as far downstream as Cincinnati, Ohio. This city draws its supply from the Ohio River about 200 miles downstream from the confluence of the Kanawha River, or about 250 miles below the Charleston industrial complex.

The Coal and Pocatalico Rivers, and other small tributaries in the lower Kanawha River Basin,were sampled during the summer and fall of 1964. Generally, water in these streams was of good quality. However, because their dry-weather flows are small, these tributaries have little effect upon the water quality of the main stem.

Ground Water

Water obtained from the alluvial deposits of the Kanawha River valley commonly is acidic and contains a high concentration of iron. This water, however, is generally softer than the bedrock water. The sulfate content is very low and fluoride is present in small amounts.

Water from the Pottsville and Allegheny formations in the study area show a wide diversity of chemical quality. In general, however, the iron content and hardness are moderate to high, fluoride content is low, and the water exhibits a slightly acid to moderately alkaline pH.

Particularly in the Charleston area, salty water is encountered in the Pottsville formation generally at depths greater than 300 feet. Deep wells along the Kanawha River in this area pump industrial brine from this formation.

VI. THE ECONOMY

Introduction

The major area of influence of the Birch Reservoir occurs on the Kanawha River at Charleston, West Virginia and below. Most of the economic data concentrates on the counties of Kanawha, Mason and Putnam. Kanawha County is a Standard Metropolitan Statistical Area. Four counties that make up the Kanawha drainage basin and which are also included in the study area are Braxton, Clay, Nicholas, and Webster. These four counties are not industrial nor do they have any urban areas.

An investigation of the population and economic characteristics and a projection of the probable growth of the area provides a basis for determining the water requirements for both water supply and water quality control. The development of an area depends not only upon the characteristics of the area itself, but also, in varying degrees upon the type and extent of the growth of the nation and the region of which it is a part. Historical and projected employment for the Ohio River Basin has been the primary frame of reference for the area under consideration. The projections were taken from the Projective Economic Study of the Ohio River Basin by the Arthur D. Little Company, Inc., Cambridge, Massachusetts, 1964. (3)

Present Economy

The topography and mineral resources of the study areas have been a major economic factor in its development. The mineral resources provided the economic base upon which employment and population increased during the first half of the Twentieth Century. The main mineral was and is coal. Much smaller amounts of natural gas, petroleum, salt, sand, and gravel are produced each year. (4) A salt deposit near Charleston has given rise to the manufacture of chlorine and together with coal and natural gas has given rise to the major employment category - chemicals and allied products. The mountainous terrain was a barrier to moving the natural resources, and it was easier to establish a chemical industry near the raw materials and ship bulk chemicals by rail than to move the coal and natural gas to another chemical center.

Agriculture was a large employer in the study area as it helped supply the food to the growing industrial population. However, with mechanization and fertilizers combining to achieve more efficient production, and with refrigeration making possible the transportation of agricultural products from outside, employment in agriculture has declined substantially. Because of the mountainous terrain, the more efficient large scale agricultural methods cannot be adopted in this area.

Since 1950, employment and population have decreased in the study area in all but the most urban section, Charleston. The great loss of job opportunities in the mines as a result of mechanized mining technology is forcing people to migrate to other areas. There has also been some decrease in coal production because of the competition from oil. Coal is still the primary resource although this industry only requires a fraction of the number of miners that it did in the past. The situation is somewhat similar in agriculture. Less people are following this pursuit as new methods of coal extraction are employed, and as improved transportation brings increased competition from outside the study area. Still, the mineral resources for the area remain the economic base for the future.

The Charleston SMSA is the dominate metropolitan center in the study area. Kanawha County has shown a relatively constant proportion of its employment in manufacturing over the past 20 years. More than one-half of the manufacturing employment in the Charleston SMSA is in the chemical industry (See Table 7).

From Table 8, the other major plants located in the study area are food and kindred products, primary metals, fabricated metals, and transportation equipment.

Future Economy

The projected values of economic indicators (Tables 6, 7, 9, 10, 11 and 12) were derived by disaggregation of the projections of the Ohio River Basin Projective Economic Study. Further study of the economy of the Kanawha River Basin in conjunction with the Ohio River Basin Water Pollution Control Project may show these projections to be too high. However, inasmuch as there is a current need for all the water the Birch Reservoir can provide for flow regulation purposes for water quality control, any later reduction in the economic projections will not affect the recommendations contained in this Birch River Report.

The study area projections include employment for Kanawha County (see Table 6) and Mason and Putnam Counties combined (see Table 7). Output tables for Kanawha, Mason, Putnam are shown separately in Tables 9, 10, and the populations for all seven counties of the study area are shown in Table 12. The urban area projections are based upon historical relationships between the urban area and the county within which the urban area is contained. (Figure III).

Extractive and manufacturing employment in Kanawha County is expected to decrease while an increase in manufacturing employment is shown in Mason and Putnam Counties. This can probably be attributed to the fact that the industrial plant sites in Kanawha County have reached a saturation point while many sites are still available for plant locations in Putnam and Mason Counties. Projections of employment in Tables 6 and 7 indicate that the most growth will occur in service categories rather than in the extractive and manufacturing categories.

Table 12 shows that the three counties nearest the Ohio River are expected to have a population increase, while the other four counties with the exception of Nicholas, will have the same or less population than in 1950.

The major increase in water use will come from increased urban population and the increase in production of chemicals. The projections of the economy section have been used for calculating future water supply and water quality control needs in subsequent sections of this report.

TABLE 6

Kanawha County

Actual and Projected Employment by Major Industry
By Decade: 1950 to 2020

	1950	1960	1980	2000	2020
Agr., For., Fish.	1,300	500	100	20	20
Mining	9,000	3,500	1,000	850	750
Construction	5,400	4,400	5,400	6,500	7,500
Manufacturing	21,430	22,750	20,000	14,790	11,390
Furniture, Lumber, Wood Products	340	250	100	80	70
Primary & Fabricated Metals	1,210	1,100	1,000	850	800
Machinery & Electrical Equipment	770	900	200	200	200
Transportation & Motor Vehicles	70	130	2,000	2,000	2,000
Other Durable Goods	3,080	3,010	1,500	100	100
Food & Kindred Products	1,150	1,480	1,080	850	700
Textile Mill Products	470	20	0	0	0
Apparel & Other Fabricated Products	40	50	30	30	30
Printing & Publishing & Allied Products	940	1,180	1,180	1,250	1,400
Chemicals & Allied Products	12,610	14,140	12,700	9,390	6,050
Other Non-Durable Goods	750	490	210	40	40
Trans., Comm., Utilities	7,400	7,900	9,000	10,000	11,000
Wholesale & Retail Trade	16,900	16,600	18,100	20,000	22,400
Finance, Insurance, Real Estate	2,200	2,600	3,300	4,200	5,000
Personal & Business Services	14,200	16,500	20,000	27,000	38,000
Government	3,400	4,000	6,000	7,800	9,800
Unreported Employment	1,100	4,200	2,740	4,100	6,320
Total	82,330	82,950	85,640	95,260	112,180

Source: U. S. Census of Population, 1950 and 1960, Bureau of the Census, U. S. Department of Commerce Historical data - Projections made within the framework of the Projective Economic Study of the Ohio River Basin, Arthur D. Little Company, Inc.

TABLE 7

Mason and Putnam Counties

Actual and Projected Employment by Major Industry By Decade: 1950 to 2020

	1950	1960	1980	2000	2020
Agr., For., Fish.	3,500	1,300	600	400	400
Mining	600	300	150	100	100
Construction	1,200	1,100	2,000	4,400	7,600
Manufacturing	2,800	4,380	5,650	6,330	6,370
Furniture, Lumber, Wood Products	150	80	80	70	70
Primary & Fabricated Metals	170	1,050	1,000	800	650
Machinery & Electrical Equipment	40	70	80	100	120
Transportation & Motor Vehicles	170	360	520	550	560
Other Durable Goods	140	190	170	170	120
Food & Kindred Products	30	100	120	140	160
Textile Mill Products	500	0	0	0	0
Apparel & Other Fabricated Products	160	90	50	50	50
Printing, Publishing & Allied Products	60	80	90	90	100
Chemicals & Allied Products	1,310	2,280	3,440	4,240	4,400
Other Non-Durable Goods	70	80	100	120	140
Trans.,Comm., Utilities	1,500	1,400	2,000	2,200	2,700
Wholesale & Retail Trade	1,400	1,900	3,000	4,000	5,000
Finance, Insurance, Real Estate	200	200	450	800	1,000
Personal & Business Services	1,400	1,800	3,000	5,000	7,000
Government	400	500	700	1,000	1,500
Unreported Employment	200	400	100	100	100
Total	13,200	13,280	17,650	24,330	31,870

Source: U. S. Census of Population, 1950 and 1960, Bureau of the Census, U. S. Department of Commerce Historical data - Projections made within the framework of the Projective Economic Study of the Ohio River Basin, Arthur D. Little Company, Inc.

Table 8

Number and Employment Size of Manufacturing Plants

(Braxton, Clay, Kanawha, Mason, Nicholas, Putnam
and Webster Counties, West Virginia)

	20-49	50-99	100-249	250-499	500-999	1,000-Over	Total
Food & Kindred Products	3	10	2	-	-	-	15
Tobacco Products	-	-	-	-	-	-	-
Textile Mill Products	-	-	-	-	-	-	-
Apparel & Related Products	-	-	-	-	-	-	-
Lumber & Wood Products	-	-	1	-	-	-	1
Furniture & Fixtures	-	-	1	-	-	-	1
Paper & Allied Products	-	-	1	-	-	-	1
Printing & Publishing	-	-	-	1	-	-	1
Chemicals & Allied Products	5	3	2	-	2	5	17
Petroleum & Coal	2	-	1	-	-	-	3
Rubber & Plastic	-	-	1	-	-	-	1
Leather Products	-	-	-	-	-	-	-
Stone, Clay, Glass	1	1	-	-	-	1	3
Primary Metals	-	-	1	1	-	-	2
Fabricated Metals	5	1	2	1	-	-	9
Machinery, except Electrical	3	-	-	2	-	-	5
Electrical Machinery	-	-	-	-	-	-	-
Transportation Equipment	1	1	-	-	2	-	4
Instruments & Related Products	-	-	-	-	-	-	-
Miscellaneous	-	-	-	-	-	-	-
Total	20	16	12	5	4	6	63

Source: Location of Manufacturing Plants by County, Industry, and Employment Size, McGraw-Hill survey of industrial plants, 1964.

Table 9
Birch Reservoir Project
Mason County, West Virginia

Output by Commodity Industry in Thousands of 1960 Dollars and Index of Output 1960=100

Industry Category	1960 Total Output (000)	1980 Index 1960=100	2020 Index 1960=100
Agriculture	$ 10,093	102.4	126.8
Mining	6,354	254.9	847.4
Construction	12,217	324.9	1,228.9
Manufacturing			
Furniture & Lumber	631	398.2	1,479.4
Primary & Fabricated Metals	23,352	148.3	420.9
Machinery, Inc. Electrical	392	258.7	636.0
Transportation Equipment & Motor Vehicles	10,211	269.4	757.7
Other Durables	978	111.2	74.6
Food & Kindred Products	2,689	234.8	918.7
Textile Mill Products	-----	-----	-----
Apparel & Allied Products	790	230.1	450.6
Printing & Publishing	497	220.7	611.7
Chemicals & Allied Products	9,481	300.0	1,500.0
Other Non-Durables	1,142	255.4	694.0

Source: Computed from the Projective Economic Study of the Ohio River Basin, Arthur D. Little Company, Inc., 1964.

TABLE 10

Birch Reservoir Project
Putnam County, West Virginia

Output by Commodity Industry in Thousands of 1960 Dollars and Index of Output 1960 = 100

Industry Category	1960 Total Output (000)	1980 Index 1960=100	2020 Index 1960=100
Agriculture	$ 5,395	99.2	68.0
Mining	1,025	----	----
Construction	10,177	336.7	1,277.5
Manufacturing			
Furniture & Lumber	378	166.1	59.5
Primary & Fabricated Metals	4,661	60.1	114.5
Machinery, inc., Electrical	989	366.6	1,007.6
Transportation Equipment & Motor Vehicles.	133	88.7	408.2
Other Durables	2,121	195.9	335.0
Food & Kindred Products	1,156	199.3	653.4
Textile Mill Products	-----	------	-----
Apparel & Allied Products	99	503.0	2,828.3
Printing and Publishing	498	310.4	1,258.2
Chemicals & Allied Products	73,684	200	400
Other-Non-Durables.	857	351.0	1,343.1

Source: Computed from the Projective Economic Study of the Ohio River Basin, Arthur D. Little Company, Inc., 1964.

Table 11
Birch Reservoir Project
Kanawha County, West Virginia

Output by Commodity Industry in Thousands of 1960 Dollars and Index of Output 1960 = 100

Industry Category	1960 Total Output (000)	1980 Index 1960=100	2020 Index 1960=100
Agriculture	$ 5,395	40.8	15.3
Mining	35,868	153.4	218.7
Construction	89,558	263.3	739.0
Manufacturing			
Furniture & Lumber	3,151	51.2	17.9
Primary & Fabricated Metals	28,487	146.8	270.1
Machinery, inc., Electrical	17,808	107.0	123.1
Transportation Equipment & Motor Vehicles.	433	525.6	1,459.1
Other Durables	49,098	83.5	12.4
Food & Kindred Products	57,011	141.2	262.5
Textile Mill Products	237	1,552.7	2,805.9
Apparel & Allied Products	496	100.4	139.3
Printing & Publishing	14,692	212.1	531.2
Chemicals & Allied Products	515,784	200.0	400.0
Other Non-Durables	14,010	74.6	30.6

Source: Computed from the Projective Economic Study of the Ohio River Basin, Arthur D. Little Company, Inc., 1964.

Table 12

Birch Reservoir Project Population 1950-2020

	1950	1960	1980	2000	2020
Mason County and Putnam County	44,500	48,100	56,600	70,100	92,300
Kanawha County	239,600	252,900	251,200	263,000	292,300
Charleston Urbanized Area (See Figure 5)	135,600	168,900	182,100	198,600	227,400
Braxton County	18,100	15,200	10,700	8,800	7,400
Clay County	15,000	11,900	10,800	10,700	11,100
Nicholas County	27,700	25,400	26,300	29,100	32,600
Webster County	17,900	13,700	13,300	13,000	13,100
Total	362,800	367,200	368,900	394,700	448,800

Source: U. S. Census of Population, 1950 and 1960, Bureau of the Census, U. S. Department of Commerce Historical data - Projections made within the framework of the Projective Economic Study of the Ohio River Basin, Arthur D. Little Company, Inc.

URBANIZED AREAS—WEST VIRGINIA

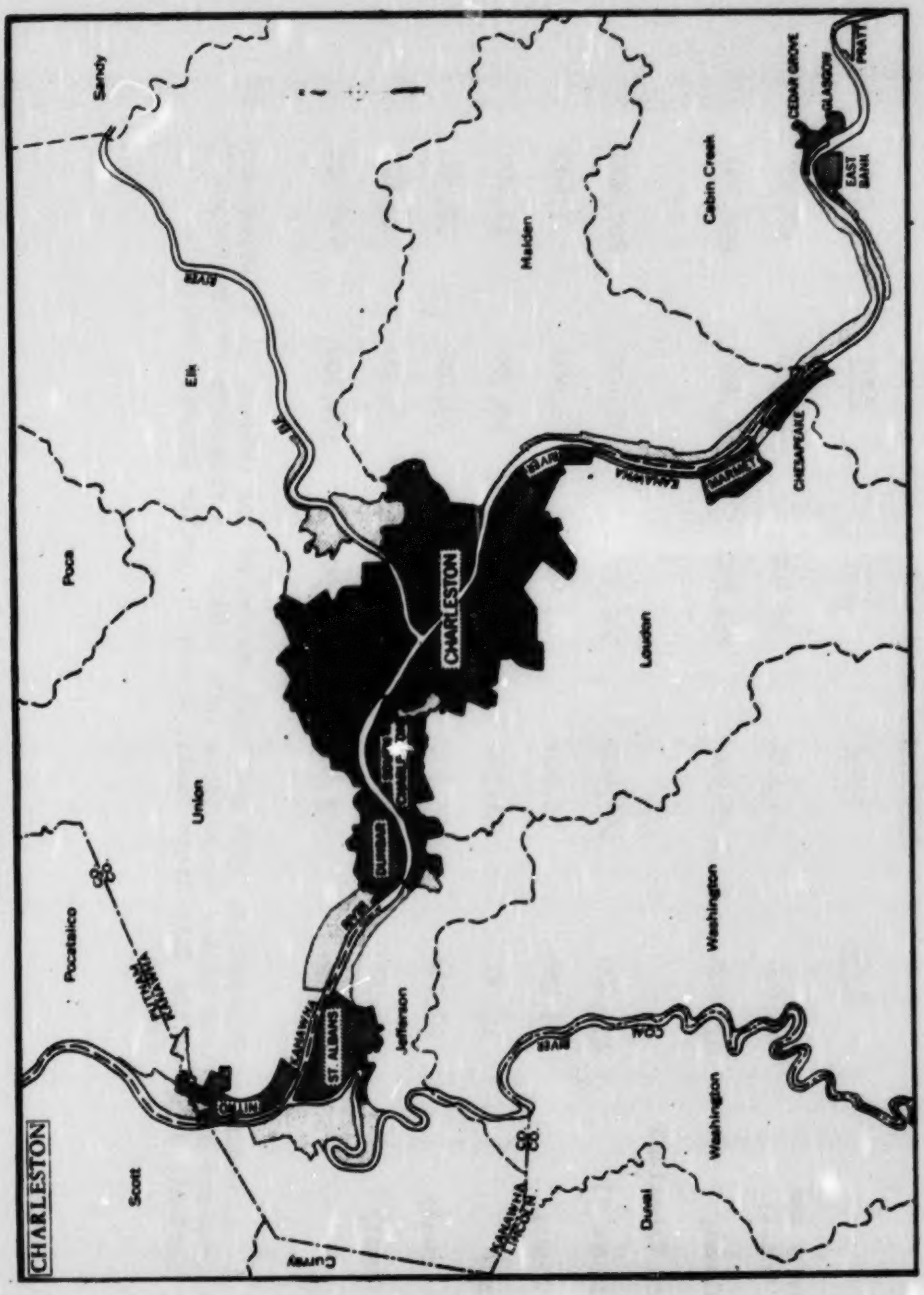

CHARLESTON
Scott
Curry
Duval
Pocatalico
Union
Jefferson
Washington
Washington
Poca
Elk
Sandy
Malden
Loudon
Cabin Creek
Chesapeake
NITRO
ST. ALBANS
DUNBAR
CHARLESTON
MARMET
EAST BANK
CEDAR GROVE
GLASGOW
PRATT
KANAWHA
PUTNAM
KANAWHA
KANAWHA
LINCOLN
ELK
RIVER
COAL
RIVER
KANAWHA
RIVER

FIGURE III

VII. WATER REQUIREMENTS - MUNICIPAL AND INDUSTRIAL

Past and Present Water Use

Water uses within the study area include domestic water supply; industrial cooling, processing, and other uses including boiler feed, sanitary, coal washing; hydroelectric and steam generating plants; navigation; transport, dispersion, and assimilation of wastes; and recreational boating. Surface water use for irrigation is limited. Boating is quite prevalent in the Kanawha River especially in the Charleston area. Water skiing is also practiced in this area; however, it is limited, as is swimming, due to the poor water quality. Since the Elk and Birch Rivers are shallow with occasional pool areas, boating is limited in these areas. Bathing in the Elk and Birch Rivers is quite prevalent even though the only organized bathing areas are at the Sutton Reservoir and at a camping area above the Birch Reservoir site. Generally, neither the Elk nor the Birch Rivers present any water quality problems, and numerous summer homes and camps dot their shores.

Present municipal and industrial water supply use in the study area is estimated to be 1,174.6 million gallons per day (mgd) (1,805 cfs) of which 1,166 mgd (1,795 cfs) is obtained from surface waters. Exhibit 3 (See Appendix A) is a summary of present municipal and industrial water sources and supplies. It has been estimated that about 1,100 mgd, or 97 percent of the total industrial water demand (1,140 mgd), is used for cooling purposes (2).

Existing Sources of Water - Surface and Ground Water

Municipal

Surface water is the major source of supply for municipal water systems in the study area shown in Exhibit 3. These surface water supplies are obtained from the Kanawha, Elk, and Coal Rivers.

The Elk River is the major contributor of surface water for municipal purposes. The Charleston Municipal Water System (West Virginia Water Company) presently delivers about 18 mgd to nearly 119,000 people. Of this amount, some 15.8 mgd is obtained from their upper intake at mile point 4.0 on the Elk River. This intake is above the backwater area of the Kanawha River.

As previously indicated, this pumping station is normally operated at its maximum capacity of 15.8 mgd. The remaining 2.2 mgd is obtained from their lower intake which is also on the Elk River but within the backwater area of the Kanawha River.

About 11 percent of the total municipal water supply is obtained from underground sources. Point Pleasant, located at the mouth of the Kanawha River, is the largest user of ground water, pumping about 0.7 mgd. This is about 6 percent of the total municipal water used within the basin.

Industrial

The major industrial use of streamflow in the study area is for cooling and occurs in the Charleston complex. Surface sources supply 1,134 mgd of the total 1,140 mgd used for industrial purposes.

Although some industrial water is furnished through the public supply systems, the greatest amount is taken directly from the river at the point of use.

Ground water supplies are used for cooling, air conditioning, and coal washing. Industrial pumpage of ground water has experienced a steady decline in the Kanawha Valley since 1954. Much of this decrease is due to the increased use of cooling towers and expansion of municipal water supply systems.

Future Municipal and Industrial Water Requirements

Municipal

If the population of communities along the Elk and Kanawha Rivers continue to grow as projected, and if the per capita demand for water continues to increase as it has over recent years, there will be a substantial increase in water needs in the basin over the next sixty years.

Municipal water use rates are affected by the size of the community, its location, habits and standard of living, availability of water, quality and cost of water, existence of sewers, extent and uses of water meters, and other variables.

The U. S. Senate Select Committee on National Water Resources, in Committee Print No. 7, states that in 1954 the average municipal water use was 147 gallons per capita per day (gpcd) and that this could conceivably increase to 185 gpcd by 1980, and to 225 by the year 2000, with a possible leveling off thereafter (11). This indicates an increase in per capita consumption of approximately 1.1 percent per year.

As indicated in Section VI, The Economy, the three counties nearest the Ohio River (Mason, Putnam and Kanawha) are projected to increase, while the remaining counties probably will have the same or possibly less population than in 1950. It is anticipated, therefore, that the municipal water use in the Charleston urbanized area and the Point Pleasant area will increase at an annual rate of 1.5 percent of the 1960 per capita figure; whereas, the remaining areas along the river will increase at an annual rate of 1.1 percent of the 1960 per capita use.

As shown in Exhibit 4, total municipal water requirements are expected to be 28.3 mgd (43.9 cfs) by 1980, 48.4 mgd (75.0 cfs) by 2000, and 59.8 mgd (92.6 cfs) by 2020.

The reach of the Kanawha River from Belle, West Virginia, to Nitro, comprises 28 miles of an industrial complex primarily of a chemical nature. In 1964, about 60,000 persons were using Kanawha River water supplied through the Belle and Nitro water purification plants. Some 50,000 persons were served by the Nitro system and the remainder by the Belle system.

As previously indicated, the Charleston filtration plant draws its raw water largely from the Elk River. The community of St. Albans obtains its water from the Coal River.

The Belle, Charleston, and Nitro water purification plants and systems are owned by the West Virginia Water Company, an affiliate of the American Water Works Company. The Charleston and Nitro distribution systems are interconnected with valved ten and sixteen-inch lines. However, the valves are closed and the two systems operate independently. The Charleston and Belle system has a valved 8-inch inter-connection which is also kept closed during normal operation.

Municipal water supply problems in the Charleston area are not of recent origin. In November 1930, about 6,500 cases of diarrhea (10.7 percent of the population) were reported to the City of Charleston. The following description of this waterborne epidemic was given:

> "The Charleston outbreak is classified "miscellaneous" under the group heading "Inadequate Water Purification," because, in spite of purification methods applied, the water was not of satisfactory quality from the standpoint of taste and odors. The true cause of the gastro-intestinal disturbances was not determined, although it was suggested by investigators that because of the high concentration of pollution and extraordinary biological character of the water, toxic substances may have developed which caused the large number of illnesses. The epidemic occurred during the period of the 1930 drought when there was little or no flow in the rivers of the Ohio Valley and when the stagnant water was devoid of oxygen and high in organic compounds. The cases were estimated from 5,000 to 8,000, the 6,500 used statistically in this report being an approximate average."(20)

Up until the Sutton Reservoir went into operation in November 1960, there were many complaints due to taste and odors from people using water from the Charleston Plant. However, since that time there have been only a few instances of complaints and these have occurred during drought conditions when a larger portion of the Kanawha River water was used.

However, consumers served by the Nitro plant have complained for years about the pronounced taste and odor of the finished water coming into their homes. The tastes and odors in the drinking water have been attributed to wastes of the chemical industry being discharged to the Kanawha River above the intake of the water utility.

The Nitro system serves the communities of Nitro, Dunbar, Institute, West St. Albans, the Spring Hill section of South Charleston, Tyler Mountain, Poca, Raymond City, and smaller unincorporated housing groups. The people in these communities became quite aroused when worms were found in the water coming into the homes in the Tyler Mountain section of the system in June 1964. These worms were identified as midge larvae. The source of the worms was traced to a 1,000 gallon, wooden-covered water tank located in a section of Tyler mountain.

Incorporated and unincorporated municipalities served by the water utility organized a committee called the Lower Kanawha Valley Clean Water Committee. The elected officials of the cities of Nitro, Dunbar, and South Charleston acting together, formed the Tri-City Water Commission. Meetings were held with Federal, State, and County agencies, the West Virginia Water Company, and the interested public. Representatives of the West Virginia Water Company reported that the company planned to spend $1.5 million to control tastes and odors by installing carbon filters at the Nitro filtration plant. This decision was made after the completion of a trial run at the plant from November 1963 through January 1964. The citizens' group was opposed to this proposal, although the Tri-City Water Commission concluded that the carbon filter system should be installed.

The citizen's committee then filed a complaint with the Public Service Commission of West Virginia against the West Virginia Water Company (12). A hearing was called by the Public Service Commission for November 18, 1964.

During the hearing the West Virginia Water Company stated that "it believes that the installation of the activitated granular carbon filter system will completely free the water of offensive taste and odor." As previously stated, the citizen's committee was opposed to this proposal and offered the following counter-proposals:

1. Take raw water directly from the Elk River.
2. Build an impoundment on Little Creek and pump Elk River water into it.
3. Impound the Coal River.

The cost of a 24-inch pipe line from the Elk River to the Nitro water plant, exclusive of rights-of-way costs was estimated by a witness of the citizen's committee to be approximately $2.9 million. Evidence supplied by the West Virginia Water Company indicated that the cost of obtaining water from the Elk River would be approximately $5.4 million, and the cost of obtaining water from the Coal River would be about $4.4 million.

The summary of findings of the Public Service Commission is as follows:

(1) The finished water from the Nitro water plant is in compliance with safe drinking water standards of the U. S. Public Health Service.

(2) The finished water from the Nitro plant is deficient as to taste and odor.

(3) The West Virginia Water Company should make a continuing study of its water supply problems, including the advisability and feasibility of obtaining a new source of raw water for its Nitro system.

It is interesting to note that in 1960, the water from the Nitro system did not meet the U. S. Public Health Standards for interstate carriers, and to this date the water from the Nitro system cannot be used for this purpose.

The Commission ordered the West Virginia Water Company to provide safe and potable water to customers supplied from its Nitro plant, and to correct the present taste and odor deficiency at the earliest practical date by means that are effective and economically feasible.

Another proposal for solving the water problem in the Charleston area was to build a 55-mile pipeline from the Summersville Dam, on the Gauley River, to Charleston. The cost of this project is estimated to be $22.0 million plus right-of-way costs.

Under present flow conditions, the Elk River is inadequate to meet future municipal water supply needs of the Charleston urbanized area. Storage in the proposed Birch Reservoir could meet future needs for water supply purposes to the year 2020, and could also help meet the existing need for low flow regulation in the Kanawha River; but consulting engineers for the West Virginia Water Company recommended another alternate plan for solving this problem.

In their "Water Supply for Charleston, Nitro, and Belle Systems" report, the West Virginia Water Company's consulting engineers stated the following reservation in the use of the Elk River to supply the anticipated 1990 water needs of 50 mgd (77 cfs) for the entire Charleston, Nitro, and Belle Systems; "The use of Elk River to supply the total demand for the three systems is conditioned, therefore, upon the Water Company reaching an agreement with the Corps of Engineers for the release of a minimum of 77 cfs from Sutton Reservoir at all times. In addition, in order to insure that the water released from Sutton Reservoir reaches the Charleston plant, the Water Company should also obtain rights to the released water from the State of West Virginia." (21) Other sources considered in this report were the Kanawha River at Belle, West Virginia, the Kanawha River at Kanawha Falls, West Virginia, and the Coal River. The Kanawha Falls site and the Coal River were ruled out as inordinately expensive, and the Elk was considered unfeasible from a supply standpoint.

On August 11, 1965, Mr. Myron R. Renick, President of the West Virginia Water Company, released information to the public relative to a $15 million improvement project for the Charleston, Nitro, and Belle water systems. The plan calls for the development of a new source of supply from the Kanawha River above the industrial Charleston complex upstream from the community of Belle, West Virginia. Raw water is to be pumped from this new source to a new modern water treatment plant which is to be built in or near Charleston and which ultimately will serve the entire area from Belle to Nitro. The water company is presently purchasing land to enable the construction of this plant. The existing Charleston water plant is to be used as an auxiliary supply, and the existing Nitro water plant will be put on a standby basis.

Engineering work for the project has started and the improvements could be completed in about three and a half years.

The natural 1-day low flow of the Elk River at its mouth, occurring on the average of once in 30 years, is 2.1 cfs. As shown in Table 3, the completion of the Sutton Reservoir in 1960 raised this 1-day, 30-year low-flow figure to 75 cfs at the reservoir. This additional flow is a result of storage capacity designed into the Sutton Reservoir mainly for the purpose of water quality control of the Kanawha River and for maintaining a satisfactory environment for fish and aquatic life in the Elk River.

The Charleston Water Plant operates its upper intake pumps at full capacity of 15.84 mgd (24.5 cfs) and utilizes the lower intake in the Kanawha back-water area to make up the remainder of their needs.

Although the West Virginia Water Company did not purchase any storage capacity in the Sutton Reservoir, they are utilizing water from this reservoir which was designed for other primary purposes.

The West Virginia Water Company has not expressed any desire to purchase storage capacity for their use in the proposed Birch Reservoir, although sufficient storage capacity could be designed for this purpose. The relatively small drainage area of the Elk River (which is entirely within West Virginia), its topography, low population density, and its limited use for agriculture and industry would ease the problem of stream water quality. On the other hand, although the water quality of the Kanawha River above Belle is almost as good as that of the Elk River (See Appendix A, Exhibits 1e and 2b), the largest drainage area, the presence of a large area of upstream land suitable for industrial development, the potential sites for hydroelectric power dams, the fact that the drainage area is divided between the States of West Virginia, Virginia and North Carolina, and that the intake by the Marmet Dam would be within the navigation pool formed, would make control of the water quality a much more difficult task than that of the Elk River.

As stated above, however, the West Virginia Water Company has indicated their acceptance of the consulting engineers recommendations and it is proceeding to solve the existing water supply problems in this manner.

Industrial

The major increase in industrial water use during the next sixty years will result from an increase in production at existing chemical plants, and from the new plants which are expected to locate within the study area. New industrial plants most probably will be situated along the Kanawha River in Putnam County as well as along the Ohio River in Mason County.

Projections of industrial water use are most difficult because they must consider the possible effects of technological developments which may occur in the industrial water use field. Industrial water use projections are made based on economic activity and unit water use for each particular industry (13). The economic activity is that outlined in the Economic Section of this report.

As shown in Exhibit 4, the total industrial use is expected to reach about 1,219 mgd in 1980; 2,176 mgd in the year 2000, and is projected to 3,913 mgd by the year 2020. The greatest single use of this water will be for cooling purposes. Use of this amount of water at any one site would not be possible. However, reuse of water is possible since the Kanawha River is canalized from its mouth to a point approximately 30 miles above Charleston, and therefore this large volume of water is made available.

No specific provision for storage of water for industrial purposes is considered in this plan for future water requirements. There is no indication that there is any need for additional water for industrial uses in this area. In the event that new or existing local water-using industries would require additional industrial water, then arrangements for reallocation of storage now allocated to water quality control or provision of additional storage would need to be considered. The industry or group of industries would pay an appropriate amount of the cost of providing such water. It is expected that any water used for industrial purposes in the Elk River Basin would be given adequate treatment prior to discharge to the stream, and would still be available for water quality control in the Kanawha River.

VIII. WATER QUALITY CONTROL

Optimum utilization of streamflow for public water supplies, industrial use, agriculture, fish and wildlife, recreation and other legitimate uses requires continued management and control of water quality. Under normal conditions a stream can assimilate, through biological process, a limited amount of organic waste. When waste loads to the stream exceed the assimilative capacity, dissolved oxygen contained in the water is depleted and septic conditions often result. Thus municipal and industrial waste-waters must be given adequate treatment before being discharged to the stream. If, after all known economically feasible and reasonable means of waste water treatment have been applied, and water quality remains degraded, then only increased streamflow can insure a suitable quality water within the stream and subsequent points of need.

Municipal and Industrial Pollution

At the present time, the water quality of the Birch and Elk Rivers presents no water quality problem and therefore, does not require any additional water for quality control purposes. See Exhibits 1a-e in the Appendix. Wastes reaching the Elk River amount to only about 5,000 population equivalents (BOD), almost all of which is of domestic origin.

The stream is able to assimilate this waste load satisfactorily. The predominant industry in the Elk River Basin is classified as wood products and employs over 430 people at about 20 different mills. These plants are small and wide-spread. Waste discharges from these industries are minimal. Occasionally, various wastes are discharged from the gas and oil industries located in the basin. These wastes would also be considered negligible after proper maintenance of plant facilities and adequate waste treatment have been effected.

Population and economic projections indicate that waste loads discharged to the Elk River will remain relatively low over the next fifty years. With adequate waste treatment, water quality in the basin should maintain its present acceptable level and should therefore, contimue to provide a satisfactory quality of water to the Charleston area for domestic and industrial purposes.

However, the Kanawha River is seriously degraded downstream from the Charleston industrial complex. See Exhibits 2a-f in the Appendix. Wastes reaching the river far exceed its natural assimilative capacity.

Since the water quality control problem of the lower portion of the Kanawha River encompasses the entire Kanawha River Basin, a special water quality control section on the matter is presented in Appendix "B" of this report. Please refer to it for additional information on present and estimated future municipal and industrial wasteload, stream conditions, storage requirements, etc.

Exhibit 8 in the Appendix shows the extent of treatment currently being given to sewered wastes at each community in the study area. No municipal waste treatment facilities presently exist in the Elk River Basin. The West Virginia Division of Water Resources reports that primary waste treatment is desirable at Sutton, Gassaway, Clay, and Clendenin. Each of these towns are developing plans to provide this treatment for their domestic wastes.

Primary waste treatment is considered to include the removal of any distinctly visible floating or settleable solids, suspended solids, scum, foam or oily slicks of unreasonable kind or quantity. With primary treatment about 40 to 60 percent of the suspended solids are separated or removed through the physical process of sedimentation. The biochemical oxygen demand (BOD) should be reduced by about 25 to 35 percent.

Agriculture contributes a very minor portion to the economy of the study area and no or little present or future stream pollution from irrigation or other agricultural operations is attributed to or expected from this source.

Water Quality Objectives

Standards of quality of receiving waters are based on threshold and limiting values for specific substances in the water and are dependent upon the beneficial water uses.

The two most essential uses of the Kanawha and Ohio Rivers below Charleston are for domestic water and industrial cooling and process water, with the domestic water being considered as the most important use.

A third important water quality consideration is that required to sustain a balanced aquatic life in the stream.

An appraisal of present surface water quality in the Elk and lower Kanawha River Basins is presented in Section V, Water Resources of the Study Area. In general, the water of the Elk River Basin presents no quality problems, while the lower Kanawha River is presently grossly polluted by municipal and industrial wastes. Several criteria, or indicators of pollution, were analyzed to determine the extent of water quality degradation caused by wastes in the Lower Kanawha River.

The dissolved oxygen (DO) concentration in water is one index of water quality. Its distribution within a river gives a measure of the balance between the oxygen supply and utilization within that system. Only from a study of the processes involved in this balance is it possible to assess the organic load which any stream network may receive without serious depletion of dissolved oxygen.

Biochemical oxygen demand (BOD) measures the amount of polluting material in water and may be defined as the quantity of oxygen utilized in the oxidation of organic matter by micro-organisms.

The first stage BOD is that portion of the oxygen demand associated with biochemical oxidation of carbonaceous material (as distinct from the subsequent second stage). Generally, the greater part, if not all of the readily oxidizable material, is consumed prior to initiation of the second phase of BOD.

Raw water for domestic purposes must be free of objectionable turbidity, color, tastes, and odors. Especially, it must be afforded a high degree of sanitary protection; that is, have a low bacteria content. Raw water must also meet certain established standards with regard to allowable concentrations of chemical elements and compounds. The BOD, preferably, should be less than 2.5 mg/l and the DO greater than 4.0 mg/l. Concentrations of inorganic phosphate of 0.01 mg/l, and inorganic nitrogen of 0.30 mg/l can be expected to produce algal blooms of such density as to cause nuisance.

Fish production is favored in near-neutral to slightly alkaline, moderately hard waters which have a relatively high dissolved oxygen content; contain sufficient nutrients for good phytoplankton production; are free of substances in toxic amounts; have low turbidities; have a temperature range within the tolerance limits (maximum of 30°C); and are subject to not more than moderate fluctuations in water levels and flow velocities (17).

The Administrative Regulations promulgated by the West Virginia State Water Resources Board on January 26, 1965 states in part that "No sewage, industrial wastes or other wastes entering any of the waters of the state shall cause or materially contribute" to certain conditions set forth "which shall be the minimum conditions allowable....." One of the conditions is that the dissolved oxygen concentration shall not be "less than 3.0 parts per million (mg/l) at the point of maximum oxygen dpeletion." The Regulations also state that the Board "reserves the right to establish more stringent conditions at its discretion, or make exceptions to these conditions in individual cases where justified."

At the present time the minimum dissolved oxygen objective of 3.0 mg/l is in effect for the Kanawha main stem. It should be noted that the West Virginia regulation for dissolved oxygen pertains to the maintenance of a minimum of 3.0 mg/l at the point of maximum oxygen depletion at all times.

The present policy of the Federal Water Pollution Control Administration prescribes that storage capacities in federal reservoirs for the purpose of streamflow regulation for the control of water quality be computed on the basis of a ten-year frequency or recurrence interval. Therefore, the quality objectives used in this report would be met nine out of every ten years and lesser dissolved oxygen concentrations would occur in the tenth year.

A minimum dissolved oxygen (DO) content of 3 mg/l would support a coarse fish population. A minimum of 5 mg/l would provide a well-balanced warm water aquatic life habitat which, if feasible, would be highly desirable.

The dissolved oxygen objective must be such as to prevent the undesirable septic conditions which now prevail in the lower reaches of the Kanawha for long periods of time during low streamflow periods.

Since storage requirements for the maintenance of 5 mg/l is unrealistic (see Exhibits 12, 13 and 14, Appendix B), a minimum DO objective of 4 mg/l has been established for this report. This objective will eliminate the septic conditions and will provide for aquatic life of a somewhat lesser quality than could be realized at 5 mg/l, but will be of substantially higher quality during nine out of every ten years than that which could be realized at 3 mg/l.

In addition to the minimum dissolved oxygen objective in the Kanawha River throughout its lower reaches, in order to mitigate further degradation of the interstate Ohio River, it is essential that a minimum objective of 5 mg/l of dissolved oxygen be maintained at the mouth of the Kanawha River.

Flow requirements are based on maintaining both of these objectives.

A maximum temperature of 28°C was used for computation purposes, along with a minimum temperature of 3°C.

Flow Regulation

The above objectives can be met by providing storage for streamflow regulation which will maintain D.O. concentrations greater than the minimum objective, except for one year out of ten, when the dissolved oxygen will drop below the minimum at the point in receiving waters where the maximum effect of pollution is felt. Streamflow regulation is considered necessary when the 7-day mean low flow, with a once-in-ten-year recurrence frequency, is inadequate to maintain the desired water quality objective. When minimum flows of less frequent occurrences prevail, flow regulation can substantially improve water quality.

There are many other desirable aspects associated with improving the quality of the streams under study. Storage requirements and the beneficial effects of its provision are assessed in view of the foregoing water quality objectives and other aspects related to water quality maintenance.

An investigation indicated that, within the limits of this study, no present or future need exists for additional flow regulation of the Elk River for water quality control purposes. Sutton Dam now assures a minimum flow of 50 cfs in the lower reach of the Elk River, and a minimum flow of 75 cfs is assured at the dam.

An immediate need for additional flow regulation for quality control was found to exist in the lower Kanawha River. (See the Water Quality Control - Kanawha River Section in Appendix "B").

Minimum flow requirements for quality control have been based on the assumption that adequate treatment will be provided all wastes prior to their discharge to the receiving streams. Even after application of adequate treatment, the pollutants reaching the stream are expected to cause adverse conditions in downstream waters. Regulations of stream flows can prevent or reduce damages from these residual materials.

While the maintenance of an acceptable dissolved oxygen level is the most general indicator of the effects of organic wastes, it is not the only criterion of importance. Concentrations of dissolved solids and nutrients which are little affected by present waste treatment methods, are decreased by dilution, thus reducing the potential for algal growth and associated taste and odor problems. Persistent organic material in industrial wastes not presently removed by treatment, are also reduced in concentration. Present waste treatment methods cannot economically remove all oxidizable organic materials, nor can they remove all nutrient, persistent, or refractory materials, so that provision of flow regulation improves water quality in ways not economically possible by treatment alone.

Provision for flow regulation, in addition to the provision of adequate waste-water treatment so that river water quality objectives are met, will increase the potential of the stream to support aquatic life and protect its use for water-oriented recreational activities. Improved river water quality will also enhance the general aesthetics of the waterway, improve the health, social, and economic environment of the resident population, contribute to the health and wellbeing of livestock and wildlife, prevent nuisance conditions, and protect and enhance land values along the stream.

The principal communities in the lower Kanawha River Valley discharging wastes to the stream below the proposed dam are Charleston, South Charleston, St. Albans, Nitro, and Dunbar, West Virginia. Quality control flows required in the Kanawha River downstream from Charleston have been determined. Required flows are based on waste loads expected from present and projected populations, plus allowances for industrial growth. Provision of adequate treatment of municipal wastes and equivalent treatment and/or control of industrial wastes has been assumed in establishing the quantity of wastes to be assimilated by the Kanawha River.

Adequate treatment, as presently defined, is the reduction of the organic waste loads by at least 85 percent of the first stage BOD at each source before discharge to the stream.

However, in the case of the Kanawha River, waste treatment processes must also reduce the second stage BOD by at least 65 percent. This reduction is necessary because of the extreme waste loads created by the Charleston complex and the factors which limit the amount of dilution water which can be provided.

If industry in the Kanawha River Valley is to increase production beyond the projected level for year 2000 (300% - See Table 11), then still more advanced waste treatment of in-plant measures will be required. The limiting factor is the amount of water that can be stored in the upper Kanawha River Basin for low-flow regulation.

On the basis of the foregoing it was found that during the month of August there is a present need for a minimum flow of about 4,700 cfs in the area below Charleston in order to maintain the DO objective of 4 mg/l. This need will increase to about 10,200 cfs by the year 2000. Lesser flows would be required during cooler months of the year. (See the Water Quality Control - Kanawha River Section in Appendix "B").

The 7-day mean annual low flow of the Kanawha River below Charleston, (River mile 54.3), with a once-in-10-year recurrence frequency, (as modified by the Sutton and Summersville Reservoirs) is 1,930 cfs. Consequently, storage to regulate streamflow is needed to control water quality.

Exhibits 12, 13 and 14 present the streamflow and storage requirements for water quality control in the lower Kanawha River for minimum DO objectives of 3, 4 and 5 mg/l. These tables indicate that in order to meet the water quality objectives previously discussed in this report, a draft-on-storage of 1,020,000 acre-feet is expected to be needed by the year 1980, 1,949,000 acre-feet by 2000, and 3,551,000 acre-feet by the year 2020. Throughout the study period, therefore, a definite need exists for storage for quality control of the Kanawha River.

Discharges from the Birch Reservoir should be coordinated with other storage releases in order to meet the water quality objectives set forth in this report. Because future demands for water quality control are much in excess of the capabilities of the Birch Reservoir, other projects in the Upper Kanawha

River Basin must be developed to meet the total draft-on-storage requirement or 1,949,000 acre-feet for the year 2000.

Reservoir releases for quality control should be adjusted on the basis of stream quality, flow, temperature, reservoir water quality, etc., at the time of release. The streamflow regimen shown in Exhibit 11, is presented as an indication of the possible release pattern to be met by the Birch Reservoir and other future developments, and also as a basis for estimating storage needs. Actual releases must be adjusted to reflect changing water quality conditions combined with consideration of data from the United States Weather Bureau's streamflow forecasting unit.

Releases should also be coordinated with information concerning anticipated stream flows available from the United States Weather Bureau's River Forecast Section.

Additional water quality control needs may be met by future reservoir developments in the Kanawha River Basin. The Federal Water Pollution Control Administration's Ohio River Comprehensive Study, presently under way, will consider future water supply and quality control needs of the area in the context of basin-wide needs. Storage in this project will be considered as a part of the Comprehensive Study.

IX. BENEFITS

Water Supply - Municipal and Industrial

Projected needs for municipal and industrial water supply were developed in preceding sections. The main point of concern for municipal water supply is in the Charleston, West Virginia area where present surface water quality below the industrial complex is unsatisfactory. The West Virginia Water Company has initiated plans to install a supplementary water intake above the industrial complex on the Kanawha River, build a new filtration plant, and upgrade the distribution system to incorporate all the water systems they control. Implementation of this plan would eliminate the problem in the Nitro, West Virginia section. It appears that benefits attributable to municipal and industrial water supply in the basin will be limited.

Water Quality Control

Water quality control benefits are defined as the net contribution to public health, safety, economy, and effectiveness in use and enjoyment of water for all purposes which are subject to detriment or betterment by virtue of change in water quality.

The value of the benefits resulting from flow regulation for quality control is the sum of the benefits for each of the quality improvements accomplished. While waste assimilation is the primary benefit derived from flow regulation for water quality control, further

TABLE 13

ALTERNATE COST OF STORAGE - SINGLE PURPOSE RESERVOIR

No.	Storage in Acre Feet	Elevation 2/ (Ft. Above M.S.L.)	Total Estimated Gross Investment	Interest Rate	Amortization Period	Average Annual Charges	Annual Operation and Maintenance	Total Estimated Average Annual Costs
1.	20,000 + Min. Pool 1/	879	$ 8,500,000	3 1/8	100 Yr.	$ 278,500	$ 44,000	$ 322,500
2.	40,000 + Min. Pool 1/	909	10,300,000	3 1/8	100 Yr.	337,400	44,000	381,400
3.	60,000 + Min. Pool 1/	932	12,100,000	3 1/8	100 Yr.	396,400	50,000	446,400
4.	80,000 + Min. Pool 1/	950	13,900,000	3 1/8	100 Yr.	455,400	55,000	510,400

1/ Minimum Pool of 5,000 acre-feet provided at each level of development for sediment storage.

2/ Elevation of each pool, including 5,000 acre-feet minimum pool. Does not include Incremental Storage provided to compensate for loss of valley storage. However, the cost of providing this storage is included in above estimates.

additional incidental benefits of a widespread nature include increased minimum flows for cooling purposes, and decreased water temperatures. The benefit of each quality improvement is considered individually and described in monetary terms where possible.

Water Temperature Control

Water temperature control has a dual benefit in that it has an industrial water supply benefit with regards to cooling water and it also has a water quality benefit.

Section VII shows that in 1965, a total of 1,140 mgd of Kanawha River water was used for industrial purposes. About 1,100 mgd were used for cooling. It is anticipated that cooling water needs will increase to about 2,100 mgd, or will about double by the year 2000. A dependable source of cooling water is essential to the operation of the thermal-electric power plants and the rapidly expanding chemical industry in the Kanawha River Valley.

Lower water temperatures are beneficial to industry in that the efficiency of heat transfer in the cooling units is improved, thereby reducing the amount of pumpage required. The reduction in fuel consumption resulting from increased plant efficiencies can result in substantial savings.

The result of these various cooling water uses is a general degradation of water quality caused by increased river water temperatures. In the Kanawha River near Charleston, the water temperature varies between 1 and 3°C above normal throughout the year.

Increased water temperatures result in greater streamflow requirements for quality control purposes when based on dissolved oxygen and the assimilation of organic wastes.

Flow regulation by the Birch Reservoir will result in a reduction in the effect of waste heat on the temperature of the Kanawha River by maintaining greater flow volumes to assimilate and subsequently dissipate the heat.

Average monthly temperatures recorded for the Elk River near its mouth and for the Kanawha River above and below the Charleston complex are listed in Table 14. Temperatures shown for Chelyan and Winfield Dam reflect the increase due to heat added by cooling water in this 40-mile reach. It was assumed that regulated discharges from the Birch Reservoir will have the same average monthly temperatures as currently observed near the mouth of the river. These temperatures were used to estimate the value of regulated Elk River flows in reducing water temperatures in the Winfield Pool below Charleston. Monetary benefits were based on the average temperature reduction that might be expected throughout the year, on a value of $0.09 per day per degree Centigrade temperature reduction per million gallons of cooling water employed. The resulting value of the benefits to cooling water users are shown as follows:

Water Temperature Control

Minimum Continuous Discharge from Birch Reservoir (cfs)	Value of Average Annual Benefit (dollars)		
	Year 1965	Year 1980	Year 2000
50	2,300	3,500	4,400
100	4,400	6,800	8,600
200	8,400	13,000	16,500

Table 14

Average Observed Monthly Water Temperatures (°Centigrade)

Month	Elk River Near Mouth	Kanawha River at Chelyan	Kanawha River at Winfield Pool
January	2.0	2.0	3.0
February	2.5	3.0	4.0
March	6.0	8.0	9.0
April	11.5	14.0	15.0
May	18.5	19.5	20.5
June	23.0	24.0	25.0
July	25.5	26.5	27.5
August	26.5	26.5	28.0
September	23.5	24.0	27.0
October	16.5	19.5	21.5
November	9.5	12.0	14.0
December	4.0	4.0	6.0

Increased Organic Waste Assimilative Capacity

It is impossible to thoroughly evaluate the monetary benefits from all improvements in water quality. Economical waste treatment methods capable of complete removal of waste materials have not been developed, and many of the other aforementioned benefits are particularly difficult to assess in monetary terms. Possible alternative methods of waste disposal or treatment that have been considered for this study include exportation of wastes to a point further downstream or out of the river basin, importation of water from an adjacent basin for dilution purposes, waste holding lagoons, periodically restocking streams, and other similar measures. None of these methods, however, has been found to be feasible for this particular situation. For this reason, only provision of storage for flow regulation is presently considered capable of achieving the required quality improvements.

It is on this basis that the value of the over-all quality control benefit has been approximated in terms of the alternate cost of equivalent flow regulation by a single-purpose reservoir constructed at one of the sites in the Kanawha River Basin currently being considered for potential development. The cost of a single-purpose reservoir at the least costly location capable of providing the same control of water quality as the proposed multi-purpose impoundment represents the minimum value of the total water quality control benefits.

Provision of storage for flow regulation planned for the Birch

Reservoir can improve the quality of the Birch and Kanawha Rivers and the reach of the Ohio River immediately downstream. The adverse effects of organic wastes remaining even after adequate treatment, as measured by the effect on dissolved oxygen, can be reduced to acceptable levels. In addition, concentrations of soluble nutrients resulting from domestic and other wastes, which are not significantly reduced by available treatment methods, can be reduced by dilution.

Although flow regulation needs in this study are based on the flow schedules developed for organic waste assimilation, provision of these flows will result in substantial improvement in other measures of stream quality. These other measures have been described on the preceding pages and are important to the many legitimate uses of the rivers involved.

To meet the projected requirements for organic waste assimilation in the Kanawha River at Charleston in 9 years out of 10 will require an annual draft-on-storage of 1,949,000 acre-feet by year 2000. (See Exhibit 13). This is much in excess of the proposed 55,900 acre-feet of reliable capacity for the proposed Birch Reservoir. Quality control in full development of the proposed reservoir, however, would provide a valuable portion of the minimum requirements for waste assimilation in the Kanawha River.

The current cost of an alternative single-purpose impoundment at the proposed Birch Reservoir site to provide storage for flow regulation for water quality control in the lower Kanawha

River may be determined from Table 13. The proposed reservoir site is capable of providing an annual draft-on-storage for the purpose of water quality control of up to about 55,900 acre-feet. Total cost, including dam structure, land acquisition, and relocations, for this volume of storage would amount to an estimated $11,731,000. Operations and maintenance costs for 55,910 acre-feet (from Table 13) would be an additional $48,800 per year.

Monetary benefits are based on an amortization period of 100 years with a Federal interest rate of 3-1/8 percent. The estimated average annual value of water quality control benefits from provision of a single purpose reservoir capable of yielding each of four representative draft-on-storage volume is tabulated below:

Water Quality Control

Annual Draft-on-Storage (acre feet)	Average Annual Benefit (dollars)
20,000	322,500
40,000	381,500
60,000	446,500
80,000	510,500

Therefore, the average annual benefit of a draft-on-storage of 55,900 acre-feet would be about $416,000. Since the requirements for water supply are less than that for water quality control, the total annual benefit, therefore, for both water supply and quality control is taken to be that benefit assignable to water quality control.

While the benefits discussed apply primarily to the Kanawha River, widespread benefits to water quality will also be realized downstream along the Ohio River.

In order to fully realize the benefits stated, it is recommended that multi-level outlets be included in the proposed Birch Reservoir Project. This would provide flexibility in reservoir operation to facilitate selecting those storage levels to supply the best downstream water quality possible and to assure that water quality objectives will be met by the project. A minimum requirement based on present knowledge of reservoir water quality would call for at least three outlets. Although variable-level outlets would be more desirable, provision of a low-level, medial-level, and near-surface level (corresponding to average reservoir operation levels) should be sufficient. Keeping in mind pertinent measures of water quality, such as pH, temperature, and dissolved oxygen, installation of recording instruments to indicate water quality at the several levels would also be a very beneficial provision, as would monitoring sites in the lower reaches of the Kanawha River.

Benefits attributed to storage in the proposed Birch Reservoir are based upon a relatively uniform passage of streamflow to the Charleston area.

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APPENDIX A

EXHIBIT 1a

SUMMARY OF WATER QUALITY - BIRCH & ELK RIVERS
Birch River at Glendon (River Mile 1.0)
September & October 1964 - 8 Samples

	Maximum	Minimum	Median
Flow, cfs	2.0	1.0	1.5
Temperature, °C	18.0	10.0	14.0
Dissolved Oxygen, mg/l	10.3	6.2	8.5
5-Day BOD, mg/l	1.7	0.3	0.9
pH	8.7	7.6	---
Specific Conductance, Micromhos	130	80	97
Acidity, Hot to Phenolphthalein, (mg/l as $CaCO_3$)	0	0	0
Alkalinity to Methyl Orange, (mg/l as $CaCO_3$)	34	12	19
Hardness, EDTA, mg/l as $CaCO_3$	40	18	25
Total Iron, mg/l	0.6	0.1	0.3
Fecal Coliform, MF, No./100 ml	30	2	9

EXHIBIT 1b

SUMMARY OF WATER QUALITY - BIRCH & ELK RIVERS
Elk River at Glendon (River Mile 80.8)
September & October 1964 - 8 Samples

	Maximum	Minimum	Median
Flow, cfs	506	310	315
Temperature, °C	17.0	9.0	15.0
Dissolved Oxygen, mg/l	10.9	8.5	9.0
5-day BOD, mg/l	2.3	0.3	0.7
pH	8.3	7.6	---
Specific Conductance, Micromhos	110	65	93
Acidity, Hot to Phenolphthalein, (mg/l as $CaCO_3$)	0	0	0
Alaklinity to Methyl Orange, (mg/l as $CaCO_3$)	29	17	21
Hardness, EDTA, mg/l as $CaCO_3$	30	22	24
Total Iron, mg/l	1.0	0.4	0.6
Fecal Coliform, MF, No./100 ml	280	82	155

EXHIBIT 1c

SUMMARY OF WATER QUALITY - BIRCH & ELK RIVERS
Elk River at Queen Shoals (River Mile 24.8)
September - October 1964 - 15 Samples

	Maximum	Minimum	Median
Flow, cfs	1212	321	478
Temperature, °C	14.0	10.0	12.0
Dissolved Oxygen, mg/l	10.6	9.2	10.0
5-day BOD, mg/l	1.6	0	0.6
pH	8.6	7.7	---
Specific Conductance, Micromhos	130	80	106
Acidity, Hot to Phenolphthalein, (mg/l as $CaCO_3$)	0	0	0
Alkalinity to Methyl Orange, (mg/l as $CaCO_3$)	31	17	24
Hardness, EDTA, mg/l as $CaCO_3$	40	24	31
Total Iron, mg/l	0.7	0.1	0.4
Fecal Coliform, MF. No./100 ml	74	2	18

EXHIBIT 1d

SUMMARY OF WATER QUALITY - BIRCH & ELK RIVERS
Elk River at Bream (River Mile 8.0)
July 1963 - 12 Samples

	Maximum	Minimum	Median
Flow, cfs	1560	160	240
Temperature, °C	28	24	26
Dissolved Oxygen, mg/l	8.9	6.9	7.6
5-Day BOD, mg/l	2.0	1.2	1.4
pH	8.0	6.6	---
Specific Conductance, Micromhos	---	---	---
Acidity, Hot to Phenolphthalein, (mg/l as $CaCO_3$)	---	---	---
Alkalinity to Methyl Orange, (mg/l as $CaCO_3$)	25	14	18
Hardness, EDTA, mg/l as $CaCO_3$	---	---	---
Total Iron, mg/l	---	---	---
Fecal Coliform, MF. No./100 ml	---	---	---

EXHIBIT 1e

SUMMARY OF WATER QUALITY - BIRCH & ELK RIVERS
Elk River at Upper Intake (River Mile 3.7)
September-October 1964 - 15 Samples

	Maximum	Minimum	Median
Flow, cfs	1620	429	645
Temperature, °C	16.0	10.0	12.0
Dissolved Oxygen, mg/l	10.4	8.9	9.5
5-day BOD, mg/l	1.3	0	0.5
pH	8.6	7.4	---
Specific Conductance, Micromhos	145	90	110
Acidity, Hot to Phenolphthalein, (mg/l as $CaCO_3$)	0.6	0	0
Alkalinity to Methyl Orange, (mg/l as $CaCO_3$)	44	12	21
Hardness, EDTA, mg/l as $CaCO_3$	42	18	29
Total Iron, mg/l	0.7	0	0.3
Fecal Coliform, MF. No./100 ml	560	72	110

EXHIBIT 2a

SUMMARY OF WATER QUALITY - KANAWHA RIVER
at Kanawha Falls (River Mile 95.2 & 94.7)
July 1963 & June, July & September 1964
28 Samples (12 for Nitrogen Analyses)

	Maximum	Minimum	Median
Flow, cfs	10,500	1.150	3300
Temperature, °C	29	22	25
Dissolved Oxygen, mg/l	9.4	7.0	8.0
5-Day BOD, mg/l	2.7	0.6	1.1
pH	9.5	6.7	---
Specific Conductance, Micromhos	1700	135	172
Acidity, Hot to Phenolphthalein, (mg/l as $CaCO_3$)	2	0	0
Alkalinity, to Methyl Orange, (mg/l as $CaCO_3$)	78	19	51
Hardness, EDTA, mg/l as $CaCO_3$	64	58	61
Total Iron, mg/l	0.9	0	0.2
Ammonia-Nitrogen, mg/l	0.20	0.04	0.09
Nitrite-Nitrogen, mg/l	0.004	0.002	0.004
Nitrate-Nitrogen, mg/l	0.40	< 0.15	0.13
Organic-Nitrogen, mg/l	0.36	0.09	0.21
Total Nitrogen, mg/l	0.64	< 0.36	0.47
Fecal Coliform, MF, No./100 ml	260	36	85

EXHIBIT 2b

SUMMARY OF WATER QUALITY - KANAWHA RIVER
at Chelyan (River Mile 73.7)
June, July, and September 1964
16 Samples

	Maximum	Minimum	Median
Flow, cfs	5500	1400	3800
Temperature, °C	31	23	26
Dissolved Oxygen, mg/l	8.7	7.3	7.9
5-Day BOD, mg/l	2.1	0.3	1.2
pH	10.2	7.5	---
Specific Conductance, Micromhos	290	155	202
Acidity, Hot to Phenolphthalein (mg/l as $CaCO_3$)	0	0	0
Alkalinity, to Methyl Orange (mg/l as $CaCO_3$)	99	43	60
Hardness, EDTA, mg/l as $CaCO_3$	---	---	---
Total Iron, mg/l	0.9	0.0	0.2
Ammonia-Nitrogen, mg/l	---	---	---
Nitrite-Nitrogen, mg/l	---	---	---
Nitrate-Nitrogen, mg/l	---	---	---
Organic-Nitrogen, mg/l	---	---	---
Total Nitrogen, mg/l	---	---	---
Fecal Coliform, MF, No./100 ml	570	80	284

EXHIBIT 2c

SUMMARY OF WATER QUALITY - KANAWHA RIVER
at Marmet Dam (River Mile 67.7)
July 1963 & June, July & Sept. 1964
13 Samples (12 for Nitrogen Analyses)

	Maximum	Minimum	Median
Flow, cfs	5800	1500	3800
Temperature, °C	34	25	28
Dissolved Oxygen, mg/l	8.4	4.0	5.4
5-Day BOD, mg/l	7.8	1.1	2.2
pH	10.4	6.7	---
Specific Conductance, Micromhos	320	190	235
Acidity, Hot Phenolphthalein, (mg/l as $CaCO_3$)	4	0	0
Alkalinity, to Methyl Orange, (mg/l as $CaCO_3$)	84	48	64
Hardness, EDTA, mg/l as $CaCO_3$	68	64	66
Total Iron, mg/l	0.6	0	0.2
Ammonia-Nitrogen, mg/l	5.0	1.7	3.0
Nitrite-Nitrogen, mg/l	0.440	0.020	0.220
Nitrate-Nitrogen, mg/l	0.60	< 0.15	0.34
Organic-Nitrogen, mg/l	1.82	0.40	0.84
Total Nitrogen, mg/l	6.84	2.44	4.25
Fecal Coliform, MF, No./100 ml	3400	60	420

EXHIBIT 2d

SUMMARY OF WATER QUALITY - KANAWHA RIVER
at St. Albans (River Mile 46.2)
13 Samples (12 for Nitrogen Analyses)
July 1963

	Maximum	Minimum	Median
Flow, cfs	6460	2630	3150
Temperature, °C	30	28	29
Dissolved Oxygen, mg/l	0.25	0	0.1
5-Day BOD, mg/l	15.5	5.7	> 8.0
pH	7.5	6.6	---
Specific Conductance, Micromhos	---	---	---
Acidity, Hot to Phenolphthalein, (mg/l as $CaCO_3$)	---	---	---
Alkalinity, to Methyl Orange, (mg/l as $CaCO_3$)	66	52	59
Hardness, EDTA, mg/l as $CaCO_3$	---	---	---
Total Iron, mg/l	---	---	---
Ammonia-Nitrogen, mg/l	5.5	1.6	3.4
Nitrite-Nitrogen, mg/l	0.100	< 0.002	0.002
Nitrate-Nitrogen, mg/l	< 0.15	< 0.15	< 0.15
Organic-Nitrogen, mg/l	1.80	0.40	1.15
Total Nitrogen, mg/l	< 6.74	< 2.25	< 5.0
Fecal Coliform, MF No./100 ml	8600	1500	4000

EXHIBIT 2e

SUMMARY OF WATER QUALITY - KANAWHA RIVER
at Winfield Dam (River Mile 31.3)
15 Samples (12 for Nitrogen Analyses)
July 1963

	Maximum	Minimum	Median
Flow, cfs	6970	2870	3500
Temperature, °C	30	28	29
Dissolved Oxygen, mg/l	3.2	0	0.8
5-Day BOD, mg/l	> 8.2	2.8	4.9
pH	8.0	6.7	---
Specific Conductance, Micromhos	---	---	---
Acidity, Hot to Phenolphthalein, (mg/l as $CaCO_3$)	---	---	---
Alkalinity, to Methyl Orange, (mg/l as $CaCO_3$)	69	45	50
Hardness, EDTA, mg/l as $CaCO_3$	---	---	---
Total Iron, mg/l	---	---	---
Ammonia-Nitrogen, mg/l	4.8	1.7	2.6
Nitrite-Nitrogen, mg/l	0.020	< 0.002	0.002
Nitrate-Nitrogen, mg/l	0.15	< 0.15	< 0.15
Organic-Nitrogen, mg/l	1.40	0.24	0.70
Total Nitrogen, mg/l	< 6.15	< 2.09	< 3.3
Fecal Coliform, MF, No./100 ml	710	< 10	100

EXHIBIT 2f

SUMMARY OF WATER QUALITY - KANAWHA RIVER
at Point Pleasant (River Mile 1.8)
16 Samples (12 for Nitrogen Analyses)
July 1963

	Maximum	Minimum	Median
Flow, cfs	7140	2940	3650
Temperature, °C	30	27	28
Dissolved Oxygen, mg/l	5.2	0.5	1.9
5-Day BOD, mg/l	6.6	1.7	3.0
pH	7.5	6.5	---
Specific Conductance, Micromhos	---	---	---
Acidity, Hot to Phenolphthalein, (mg/l as $CaCO_3$)	---	---	---
Alkalinity, to Methyl Orange, mg/l as $CaCO_3$	62	46	49
Hardness, EDTA, mg/l as $CaCO_3$	---	---	---
Total Iron, mg/l	---	---	---
Ammonia-Nitrogen, mg/l	5.0	0.5	2.2
Nitrite-Nitrogen, mg/l	0.004	< 0.002	0.002
Nitrate-Nitrogen, mg/l	0.15	< 0.15	< 0.15
Organic-Nitrogen, mg/l	1.65	0.46	0.68
Total Nitrogen, mg/l	< 4.64	< 1.41	< 2.6
Fecal Coliform, MF, No./100ml	< 10	< 2	0

EXHIBIT 3

MUNICIPAL AND INDUSTRIAL WATER USE - 1960

LOCATION	Population Served	Municipal (GPD) Surface	Municipal (GPD) Ground	Industrial (GPD) Surface	Industrial (GPD) Ground
ELK RIVER BASIN					
Clay	1,200	72,000			
Clendenin	3,400	150,000			
Falling Rock				6,480,000	
Gassaway	1,500	130,000			
Sutton	970	86,000			
Sub-Total	7,070	438,000		6,480,000	
KANAWHA RIVER BASIN					
Alloy	1,600	200,000		40,000,000	
Bancroft	1,415	150,000		200,000	
Belle	9,000	940,000		900,000	
Industries (Self-supplied)				197,500,000	200,000
Boomer	1,600	153,000			
Buffalo	800		100,000		
Cabin Creek (Source No. 2)	550	28,000			
Cannelton	240		24,000		486,000
Cedar Grove	1,915	205,000			
Charleston	119,000	7,730,000		9,260,000	
Industries (Self supplied)				351,000,000	5,000,000
Charleton Heights	600	48,000			
Chelyan	1,880	80,000			
Eleanor	1,200		80,000		
Gauley Bridge	1,225	72,000			
Glen Ferris	350	60,000			
Handley	500	20,000			
Montgomery	6,140	380,000			
Nitro	50,000	3,250,000		2,100,000	
Industries (Self-supplied)				39,000,000	600,000
Point Pleasant	10,000		700,000		
Powellton	1,100	100,000			
Pratt	1,200	60,000			
St. Albans	15,000	750,000		350,000	
Industries (Self-supplied)				275,000,000	
Smithers	2,550		280,000		
Ward	1,110		139,000		
Winfield	400	20,000			
SUB-TOTAL:	229,375	1,246,000	1,323,000	915,310,000	6,286,000
TOTAL:	236,445	14,684,000	1,323,000	921,790,000	6,286,000

EXHIBIT 4

PROJECTED MUNICIPAL AND INDUSTRIAL WATER USE

LOCATION:	WATER SUPPLY REQUIREMENTS - MGD 1960	1965	1980	2000	2020
ELK RIVER BASIN					
Municipal	0.438	0.553	0.595	0.790	1.023
Industrial	-----	-----	-----	-----	-----
KANAWHA RIVER BASIN					
Charleston Urbanized Area					
Municipal	10.984	19.800	22.995	40.268	49.315
Industrial	915.310	1,140.200	1,218.100	2,174.600	3,912.200
Falls District					
Municipal	0.837	0.978	1.402	2.042	2.465
Industrial	0.811	0.836	0.906	1.062	1.218
Kanawha District					
Municipal	0.480	0.580	0.880	1.410	1.864
Industrial	-----	-----	-----	-----	-----
Cabin Creek District					
Municipal	0.199	0.241	0.369	0.587	0.773
Industrial	-----	-----	----	-----	-----
Buffalo District					
Municipal	0.100	0.115	0.162	0.230	0.273
Industrial	-----	-----	-----	-----	-----
Poca District					
Municipal	0.230	0.279	0.425	0.681	0.893
Industrial	0.200	0.281	0.523	1.028	1.534
Scott District					
Municipal	0.020	0.024	0.037	0.059	0.078
Industrial	-----	-----	-----	-----	-----
Point Pleasant					
Municipal	0.700	0.871	1.383	2.296	3.112
Industrial	-----	-----	28.240	61.030	93.820
TOTAL MUNICIPAL: :	13.988	23.441	28.248	48.363	59.796
TOTAL INDUSTRIAL:	916.121	1,141.317	1,219.006	2,175.662	3,913.418

NOTE: Industrial requirement includes municipal-supplied water.

EXHIBIT 5

Projected Municipal Water Requirements

	Location	Population Served	Domestic Water Use (mgd)	Water Supplied To Industries (mgd)	Total Municipal (mgd)
1960	Clay	1,200	0.072	--	0.072
	Clendenin	3,400	0.150	--	0.150
	Charleston	99,820	6.488	7.736	14.224
	South Charleston	19,180	1.246	1.527	2.773
	Nitro	39,000	2.535	3.023	5.558
	Dunbar	11,000	0.715	0.853	1.568
1980	Clay	1,308	0.141	--	0.141
	Clendenin	4,413	0.294	--	0.294
	Charleston	151,730	13.320	12.184	25.504
	South Charleston	29,150	2.560	2.431	4.991
	Nitro	59,260	5.210	4.794	10.004
	Dunbar	16,720	1.470	1.452	2.922
2000	Clay	1,452	0.217	--	0.217
	Clendenin	5,508	0.451	--	0.451
	Charleston	204,000	23.210	19.636	42.846
	South Charleston	39,950	4,600	3.784	8.384
	Nitro	80,040	9.200	7.606	16.806
	Dunbar	22,580	2.590	2.318	4.908
2020	Clay	1,594	0.274	--	0.274
	Clendenin	6,613	0.571	--	0.571
	Charleston	233,780	29.200	24.358	53.558
	South Charleston	45,770	5.700	4.780	10.480
	Nitro	91,400	10.500	10.507	21.007
	Dunbar	26,680	3.070	3.065	6.135

EXHIBIT 6

MUNICIPAL AND INDUSTRIAL WASTE DISCHARGES ELK AND KANAWHA RIVER BASINS 1960

LOCATION	MUNICIPAL		INDUSTRIAL & COMMERCIAL	
	Waste Water (mgd)	Estimated Discharge (Pop.Equiv.)	Waste Water (mgd)	Estimated Discharge (Pop. Equiv.)
Elk River				
Sutton	0.086	530		
Gassaway	0.130	1430		
Clay	0.072	330		
Clendenin	0.150	1160		
Falling Rock	--	40		
Residual at mouth		1230		
Kanawha River				
Gauley Bridge	0.090	740		
Glenn Ferris	0.032	50		
Charleton Heights	0.048	90		
Alloy	0.525	20	0.325	
Boomer	0.155	250		
Powellton	0.100	190		
Smithers	0.208	2230		
Cannelton-Carbondale	0.098	160		
Montgomery	0.400	2240		
Handley	0.020	140		
Pratt	0.060	310		
Glasgow	0.053	300		
Cedar Grove	0.092	1170		
Ward	0.020	170		
East Bank	0.060	830		
Cabin Creek	0.030	120		
Chelyan	0.108	75		
Chesapeake	0.320	575		
Belle	0.180	1575	0.900	147,000
Marmet	0.320	1225		
Levi-Rand	0.200	380		
Malden	0.120	150		
Charleston	5.470	63,000	2.400	30,000
South Charleston	1.200	13,420	3.000	565,570
East Kanawha Estates	0.060	350		
Dunbar	0.690	7,000	0.150	1,540
Institute	0.070	160	1.200	314,040
W.Va. State College	0.110	2500		
St. Albans	0.700	8100	0.350	3,020
Residual from Coal River		1100		
Nitro	0.510	3780	0.900	71,920

EXHIBIT 6 (continued)

MUNICIPAL AND INDUSTRIAL WASTE DISCHARGES
ELK AND KANAWHA RIVER BASINS
1960

LOCATION	MUNICIPAL Waste Water (mgd)	MUNICIPAL Estimated Discharge (Pop.Equiv.)	INDUSTRIAL & COMMERCIAL Waste Water (mgd)	INDUSTRIAL & COMMERCIAL Estimated Discharge (Pop.Equiv.)
Kanawha River (continued)				
Poca	0.090	350		
Bancroft	0.070	240	0.200	
Eleanor	0.031	270		
Winfield	0.020	130		
Residual from Hurricane Creek		280		
Buffalo	0.100	230		
Henderson	0.070	250		
Point Pleasant	0.630	1100		

EXHIBIT 7

ELK RIVER AT COONSKIN SHOALS

Municipal Water Supply Storage Requirements

*Storage Requirements in Acre Feet
for Various Drought Periods for the Projected
Combined Needs of the
Charleston, Nitro, and Belle Water Systems

		YEAR (Projected Flow Required)			
WATER YEAR	DAYS	2020 (141 cfs)	2000 (113 cfs)	1980 (67 cfs)	1960 (37 cfs)
1930-1931	176	41,382	31,688	16,818	7,543
1953-1954	120	26,742	20,179	9,610	3,430
1952-1953	77	13,804	9,541	3,617	415
1936	75	8,795	5,557	1,472	65

Average of the two worst drought years:

1930-1931 and 1953-1954	148	34,062	25,934	13,214	5,487

Other drought years of lesser duration and less severe low flows include:

1939, 1940, 1944, 1946, and 1957.

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* Records reviewed for the last 35 years. Storage requirements based on natural stream flows and do not reflect the effects of Sutton Reservoir.

APPENDIX B

WATER QUALITY CONTROL

KANAWHA RIVER

Extensive use of the Kanawha River for cooling purposes by industries in the Belle, South Charleston, Institute, and Nitro areas causes an increase in water temperature of from 1 to 3°C. In addition to the major chemical plants along the river, the Appalachian Power Company has two thermal-electric power plants which also require significant quantities of cooling water. One plant is located at Glasgow (river mile 78.4) and produces 430,000 kilowatts; the other is located at Cabin Creek (river mile 74.4) and produces 307,000 kilowatts. Stream temperatures as high as 30 degrees Centigrade (86°F) occur in the river downstream from Charleston.

Pollutants in receiving waters are frequently classified as degradable or nondegradable. Degradable constituents are altered or removed from solution or suspension by natural (chemical, biological, or physical) purification processes (16). Thus, carbonaceous domestic and industrial wastes may be converted largely to carbon dioxide, part of which may escape to the atmosphere. Ammonia, of particular concern in the lower Kanawha River, may be oxidized biochemically to nitrates, then assimilated during algal synthesis. Nondegradable constituents, such as chlorides, sulphates, color, and hardness, are not readily decomposed, altered biochemically, or removed as a result of natural processes. Only dilution can substantially reduce the concentration of these substances in the stream.

Heavy metals may be precipitated as insoluble salts and removed by sedimentation. Economical means of removing all the organic and inorganic substances found in wastes have not been developed. Excessive quantities of these wastes render the downstream Kanawha River unsuitable as a source of domestic water supply. The end-products of biochemical stabilization (carbonates, nitrates, phosphates) through conventional sewage treatment and natural stream purification are classed as nondegradable.

The effect upon the receiving stream during the natural process of waste assimilation is primarily one of oxidation resulting in exhaustion of the dissolved oxygen and causing septic conditions. The rate, or extent, of oxidation is influenced by temperature, pH, concentration of pollutants, the presence of toxic substances, and a number of environmental factors. Annually, during the summer and fall months, when streamflow is low and temperature high, the Kanawha River becomes grossly degraded as a result of its inability to assimilate the great volume of municipal and industrial wastes.

Relationships between dissolved oxygen content, flow, and municipal and industrial waste loads have been determined from base calculations performed by staff members of the Technical Advisory and Investigations Section, Taft Sanitary Engineering Center, Cincinnati, Ohio. This office used stream conditions observed during a July 1963 survey in formulating a methematical model of oxygen balance for the Kanawha River.

Critical stream temperatures for each of the four seasons of the year were developed from an evaluation of the existing stream records.

A critical stream temperature of 27°C was used for the summer season from mile point 73.7 to 55.0, and from mile point 14.6 to the confluence with the Ohio River. However, a temperature of 28°C was used from mile point 55.0 to 14.6.

Critical temperatures of 3°, 9°, and 21°C were used for the entire Lower Kanawha for the other three seasons.

It was determined that due to the extreme waste volumes being produced and the factors limiting the amount of dilution which could be provided, a very high degree of municipal and industrial waste treatment within the Kanawha River Basin must be obtained. It was assumed that treatment practices would be such as to accomplish an 85 percent reduction in the first stage BOD as well as a 65 percent reduction in the second stage BOD.

Critical streamflow conditions were considered to be that of the 7 consecutive day low stream flow, which is exceeded in nine out of ten years.

Water quality objectives during this critical low flow condition were for a minimum dissolved oxygen content of 3 mg/l within any reach of the Kanawha River, and for a minimum dissolved oxygen content of 5 mg/l at the mouth of the Kanawha River.

Municipal and industrial waste loads were determined for the year 1960 with subsequent projection to the years 1965, 1980, 2000 and 2020. (See Exhibits 9a-f). A summation of current municipal waste loads was made from data contained in publications of the U. S. Census Bureau (9); the Public Health Service (10) (15), and information furnished by the West Virginia Division of

Water Resources. (See Exhibit 8). Future industrial and commercial waste loads were projected in proportion to the expected increase in monetary value of chemicals and allied products produced. (See Tables 9, 10, and 11). As pointed out in Section VI, the chemical industry will continue to dominate the economy of the study.

Waste loads emanating from commercial and light industrial sources were estimated on the basis of population served by the municipal sewage treatment plants. Charleston, for example, with a population served of 99,000, added an estimated 50 percent additional population equivalents (P.E.) to the Kanawha River from these sources. Similarly, South Charleston, St. Albans, and Dunbar, with populations in the 10,000 to 25,000 range, were each assumed to contribute an additional 20 percent. Communities with populations less than 10,000 were not considered likely to support a significant number of waste-producing commercial or light industrial plants.

In 1965, the total domestic waste load originating in the fifty-mile length between London and Winfield Dams amounted to about 225,850 P.E. before treatment. Likewise, the first stage BOD waste loads from establishments in this portion of the Kanawha River, prior to treatment was equivalent to a total population of about 7,670,000, of which about 98 percent was contributed by the eight largest chemical plants in the valley. (See Exhibits 9a-f). In addition to this waste load the industries in the Kanawha Valley also contribute about 936,500 pounds of second stage BOD to the river each day. There is no firm comparison between this second stage BOD and normal domestic waste and therefore, it cannot be reported in terms of population equivalents.

1965 Industrial and Commercial Raw Waste Loadings	First Stage BOD in P.E.'s	Second Stage BOD in lbs/day
Belle (RM 68.5)	1,350,000	200,000
Charleston (RM 55.0)	2,100,000	102,500
Institute (RM 49.0)	3,600,000	514,000
Nitro (RM 43.0)	620,000	120,000
TOTAL	7,670,000	936,500

The West Virginia Division of Water Resources has worked closely with the major industries that discharge wastes to the Kanawha River and have provided information regarding these waste loadings for the development of this study.

The major industrial loads discharged to the Kanawha River are listed in Exhibit 10. Currently, these industries remove approximately 40 percent of the biochemical oxygen demand from their 1958 waste-loads. They have been directed by the West Virginia Division of Water Resources to reduce these present loads by 50 percent before June 30, 1966. This would mean an overall reduction of about 70 percent of their untreated 1958 loads. Population projections and indices of industrial expansion were developed in Section VI of this report. These forecasts (presented in Exhibits 9a-f) were applied to current domestic and heavy industrial waste loads at six major population centers. Domestic, commercial, and light industrial waste loads discharged to the Kanawha River were projected in proportion to the increase of population in the Charleston Urbanized Area, which includes most of the densely populated area along the river in Kanawha County.

Although it is probable that methods will be devised within the next fifty years to recover some of the chemical product wastes that are presently being discharged to the river, it is also likely, in this rapidly expanding field, that other chemicals will be developed which will, in turn, have comparable quantities of unrecoverable by-products. Thus, projections of future waste loads from heavy industry (predominately chemicals and allied products) were based upon the values of product output, i.e., a 200 percent increase by the year 1980, a 300 percent increase by 2000, and a 400 percent increase by the year 2020.

Exhibits 11a-g are curves which have been developed for the critical section of the Kanawha River by using the mathematical model for oxygen balance. These curves are for various seasonal stream temperatures, various degrees of treatment prior to discharge to the stream, and for the waste loads existing in 1965, as well as those expected in the years 1980, 2000, and 2020, in accordance with the economic projections for that area. The curves are preliminary at this time and are subject to further refinement as the comprehensive study of the Ohio River Basin progresses.

The 7-day mean annual low flow of the Kanawha River below Charleston, (river mile 54.3), with a once-in-ten-year recurrence frequency, is 1,930 cfs. This flow was used in this study to determine the need for stream flow regulation for quality control. Exhibits 11a and 11b show that there is an immediate need for reservoir storage capacity for quality control of the Kanawha River.

To determine this storage need, an analysis was made of the monthly average flows at the USGS gage below Charleston for the period of record (1939-1963). It should be noted that USGS flow records at this location are indefinite (during low-flow periods) and have been estimated on the basis of records for the Kanawha River at Kanawha Falls and tributary inflow.

Exhibits 12, 13 and 14 present the streamflow and storage requirements for water quality control for the years 1965, 1980, 2000 and 2020 for minimum DO objectives of 3, 4 and 5 mg/l. The annual draft-on-storage required to assure the needed flows has been estimated from monthly mean discharges available below Charleston, constituting the annual total that must be available to supplement minimum streamflows that may be expected to occur in nine years out of ten.

Because of the great expense involved in eventually supplying this water, it is concluded that intensive additional studies necessarily must be continued in several reaches of the Kanawha River in and below the Charleston industrial complex before a final evaluation is feasible. It is, therefore, very important that the projected needs (as outlined in this report) for the years 2000 and 2020 be highly qualified and considered to be very preliminary in nature at this time.

EXHIBIT 8

PRINCIPAL SOURCES OF MUNICIPAL WASTES
ELK AND KANAWHA RIVER BASINS
1960

Community	Miles Above Mouth	Approximate Sewered Population	Treatment Currently Required*	Treatment Given* (1965)
ELK RIVER				
Sutton	98	930	P	Planning
Gassaway	93	1,370	P	Planning
Clay	52	500	P	Planning
Clendenin	22	1,600	P	Planning
Falling Rock	17	270	P	None
KANAWHA RIVER				
Gauley Bridge	97	1,000	S	Planning
Glen Ferris	95	320	S	Planning
Charleton Heights	02	640	S	Planning
Alloy	90	160	S	Planning
Boomer	89	1,760	S	Planning
Powellton	95	1,330	P	None
Cannelton-Carbondale	88	1,100	P	None
Smithers	87	2,360	S	P
Montgomery	86	3,400	S	P
Handley	83	950	S	None
Pratt	82	640	S	Septic Tank
Glasgow	77	1,000	S	P
Cedar Grove	77	1,730	S	Planning
Ward	81	1,170	P	None
East Bank	76	1,130	S	P
Cabin Creek	75	850	S	Planning
Chelyan	74	530	S	Planning
Chesapeake	71	2,970	S	P
Belle	69	2,710	S	Constructing(P)
Marmet	67	2,750	S	None
Levi-Rand	64	2,750	S	None
Malden	62	1,060	S	P
Charleston	56	99,000	S	P
So. Charleston	56	21,100	S	P (Planning S).
E. Kanawha Estates	56	550	P	P
Dunbar	51	12,100	S	P (Planning S).

EXHIBIT 8 (continued)

PRINCIPAL SOURCES OF MUNICIPAL WASTES
ELK AND KANAWHA RIVER BASINS
1960

Community	Miles Above Mouth	Approximate Sewered Population	Treatment Currently Required*	Treatment Given* (1965)
KANAWHA RIVER (continued)				
Institute	49	1,140	S	Septic Tank
W. Va. State College	49	2,500	S	None
St. Albans	46	16,610	S	P (Planning S)
Nitro	43	7,590	S	P (Planning S)
Poca	39	670	S	Constructing
Bancroft	35	520	S	None
Eleanor	34	770	S	None
Winfield	33	350	S	None
Buffalo	22	440	S	None
Henderson	0	610	S	Constructing
Point Pleasant		5,820	S	S
TOTAL:		206,750		

*Information provided by West Virginia Division of Water Resources.

P - Primary treatment with post-chlorination.

S - Secondary Treatment with post-chlorination.

EXHIBIT 9a

Municipal and Industrial Waste Loads Discharged to the Lower Kanawha River
Belle Area (RM 68.5)

				First Stage Carbonaceous BOD				Second Stage BOD*	
		Population	Industrial	Treated Load in PE		Treated Load in #/day		Treated Load in #/day	
Year	Source	Served	Output	None	85%	None	85%	None	65%
1960									
	Municipal	5,000 (=100)		5,000	750				
	Industrial		100	1,100,000	165,000				
	Total			1,105,000	165,750	265,200	39,800	160,000	56,000
1965									
	Municipal	113		5,650	848				
	Industrial		125	1,350,000	202,500				
	Total			1,355,650	203,348	325,400	48,800	200,000	70,000
1980									
	Municipal	152		7,600	1,140				
	Industrial		200	2,200,000	330,000				
	Total			2,207,600	331,140	530,000	79,600	320,000	112,000
2000									
	Municipal	205		10,250	1,538				
	Industrial		300	3,300,000	495,000				
	Total			3,310,250	496,538	795,000	119,100	480,000	168,000
2020									
	Municipal	235		11,750	1,763				
	Industrial		400	4,400,000	660,000				
	Total			4,411,750	661,763	1,055,000	157,200	640,000	224,000

* Second Stage BOD = 4.57 x Ammonia-Nitrogen Waste Load

EXHIBIT 9b

Municipal and Industrial Waste Loads Discharged to the Lower Kanawha River
Charleston Area (RM 55)

				First Stage Carbonaceous BOD				Second Stage BOD*	
				Treated Load in PE		Treated Load in #/day		Treated Load in #/day	
Year	Source	Population Served	Industrial Output	None	85%	None	85%	None	65%
1960									
	Municipal	158,500(=100)		158,500	23,800				
	Industrial		100	1,680,000	252,000				
	Total			1,838,500	275,800	437,000	65,600	82,000	28,700
1965									
	Municipal	113		179,000	26,900				
	Industrial		125	2,100,000	315,000				
	Total			2,279,000	341,900	542,000	81,400	102,500	35,900
1980									
	Municipal	152		241,000	36,200				
	Industrial		200	3,360,000	504,000				
	Total			3,601,000	540,200	865,000	103,000	164,000	57,500
2000									
	Municipal	205		325,000	48,700				
	Industrial		300	5,050,000	757,000				
	Total			5,375,000	805,700	1,290,000	194,000	246,000	86,100
2020									
	Municipal	235		372,000	55,800				
	Industrial		400	6,720,000	1,010,000				
	Total			7,092,000	1,065,800	1,700,000	254,000	328,000	115,000

* Second Stage BOD = 4.57 x Ammonia-Nitrogen Waste Load

EXHIBIT 9c

Municipal and Industrial Waste Loads Discharged to the Lower Kanawha River Institute Area (RM 49)

				First Stage Carbonaceous BOD				Second Stage BOD*	
				Treated Load in PE		Treated Load in #/day		Treated Load in #/day	
Year	Source	Population Served	Industrial Output	None	85%	None	85%	None	65%
1960									
	Municipal	14,540 (=100)		14,540	2,180				
	Industrial		100	2,880,000	432,000				
	Total			2,894,540	434,180	695,000	104,000	410,000	143,500
1965									
	Municipal	113		16,400	2,430				
	Industrial		125	3,600,000	540,000				
	Total			3,616,400	542,430	866,000	130,000	514,000	179,500
1980									
	Municipal	152		22,100	3,320				
	Industrial		200	5,770,000	866,000				
	Total			5,792,100	869,320	1,387,000	206,000	810,000	283,000
2000									
	Municipal	205		29,800	4,460				
	Industrial		300	8,660,000	1,300,000				
	Total			8,689,800	1,304,460	2,040,000	306,000	1,230,000	430,000
2020									
	Municipal	235		34,200	5,130				
	Industrial		400	1,155,000	1,730,000				
	Total			1,189,200	1,735,130	2,200,000	330,000	1,640,000	574,000

* Second Stage BOD = 4.57 x Ammonia-Nitrogen Waste Load

EXHIBIT 9d

Municipal and Industrial Waste Loads Discharged to the Lower Kanawha River
Nitro Area (RM 43)

Year	Source	Population Served	Industrial Output	First Stage Carbonaceous BOD				Second Stage BOD*	
				Treated Load in PE		Treated Load in #/day		Treated Load in #/day	
				None	85%	None	85%	None	65%
1960									
	Municipal	21,995 (=100)		21,995	3,300				
	Industrial		100	496,000	74,500				
	Total			517,995	77,800	18,650	2,800	96,000	33,600
1965									
	Municipal	113		24,800	3,720				
	Industrial		125	620,000	93,000				
	Total			644,800	96,720	23,200	3,480	120,000	42,000
1980									
	Municipal	152		33,400	5,000				
	Industrial		200	994,000	149,000				
	Total			1,027,400	154,000	37,000	5,550	192,000	67,200
2000									
	Municipal	205		45,100	6,260				
	Industrial		300	1,490,000	224,000				
	Total			1,535,100	230,260	55,200	8,290	288,000	101,000
2020									
	Municipal	235		51,600	7,750				
	Industrial		400	1,990,000	298,000				
	Total			2,041,600	305,750	74,000	11,100	384,000	134,000

* Second Stage BOD = 4.57 x Ammonia-Nitrogen Waste Load

EXHIBIT 9e

Municipal and Industrial Waste Loads Discharged to the Lower Kanawha River
Putnam County Area (RM 25)

				First Stage Carbonaceous BOD				Second Stage BOD *	
Year	Source	Population Served	Industrial Output	Treated Load in PE		Treated Load in #/day		Treated Load in #/day	
				None	85%	None	85%	None	65%
1960									
	Municipal	2,490 (=100)		2,490	370				
	Industrial			---	----				
	Total			2,490	370	600	90	6,000 (=100)	2,100
1965									
	Municipal	112		2,790	420				
	Industrial			----	----				
	Total			2,790	420	670	100	7,000 (=125)	2,450
1980									
	Municipal	139		3,880	580				
	Industrial		100	41,700	6,240				
	Total			45,580	6,820	11,000	1,650	12,000 (=200)	4,200
2000									
	Municipal	165		6,400	960				
	Industrial		150	62,500	9,370				
	Total			68,900	10,330	16,500	2,480	18,000 (=300)	6,300
2020									
	Municipal	178		11,400	1,710				
	Industrial		200	83,500	12,500				
	Total			94,900	14,210	20,000	3,000	24,000 (=400)	8,400

* Second Stage BOD = 4.57 x Ammonia-Nitrogen Waste Load

EXHIBIT 9f

Municipal and Industrial Waste Loads Discharged to the Lower Kanawha River
Mason County Area (RM 10)

Year	Source	Population Served	Industrial Output	First Stage Carbonaceous BOD				Second Stage BOD*	
				Treated Load in PE		Treated Load in #/day		Treated Load in #/day	
				None	85%	None	85%	None	65%
1960	Municipal	500 (=100)		500	75	120	18		
	Industrial								
	Total			500	75	120	18		
1965	Municipal	101		505	76				
	Industrial								
	Total			505	76	121	18.2		
1980	Municipal	120	100	600	90				
	Industrial		100	8,350	1,250				
	Total			8,950	1,340	2,150	323		
2000	Municipal	170		850	127				
	Industrial		150	12,500	1,875				
	Total			13,350	2,002	3,200	480		
2020	Municipal	194		970	145				
	Industrial		200	16,700	2,500				
	Total			17,670	2,645	4,240	635		

*Second Stage BOD = 4.57 X Ammonia-Nitrogen Waste Load

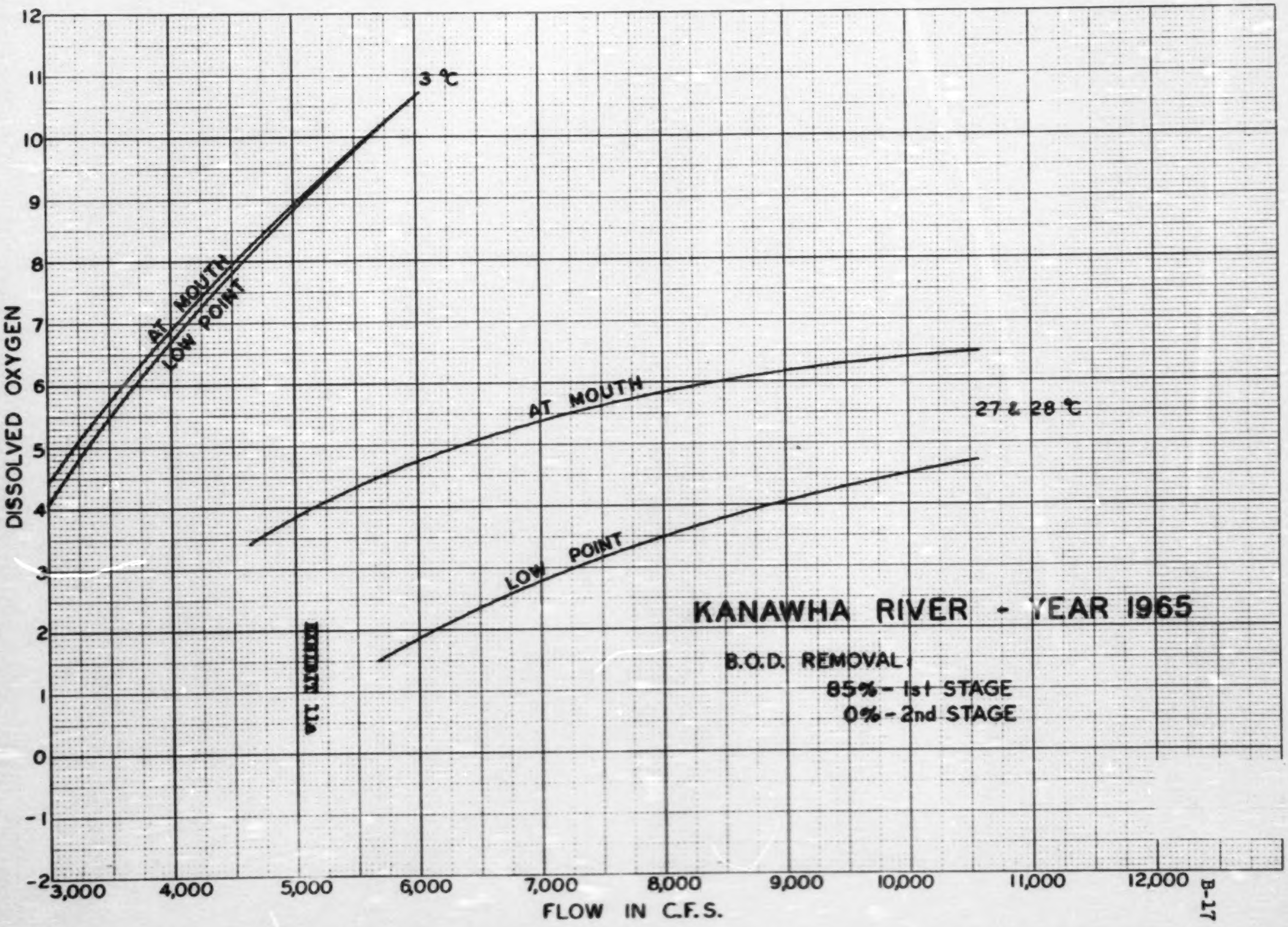
EXHIBIT 10

MAJOR SOURCES OF INDUSTRIAL WASTES DISCHARGED TO THE KANAWHA RIVER

1965

Area	5-Day BOD Waste Load (#/Day)
Belle	35,000 (Summertime)
South Charleston	406,000
Institute	75,000
Nitro	149,000

EXHIBIT 11a


KANAWHA RIVER - YEAR 1965

B.O.D. REMOVAL:
85% - 1st STAGE
0% - 2nd STAGE

EXHIBIT 11b

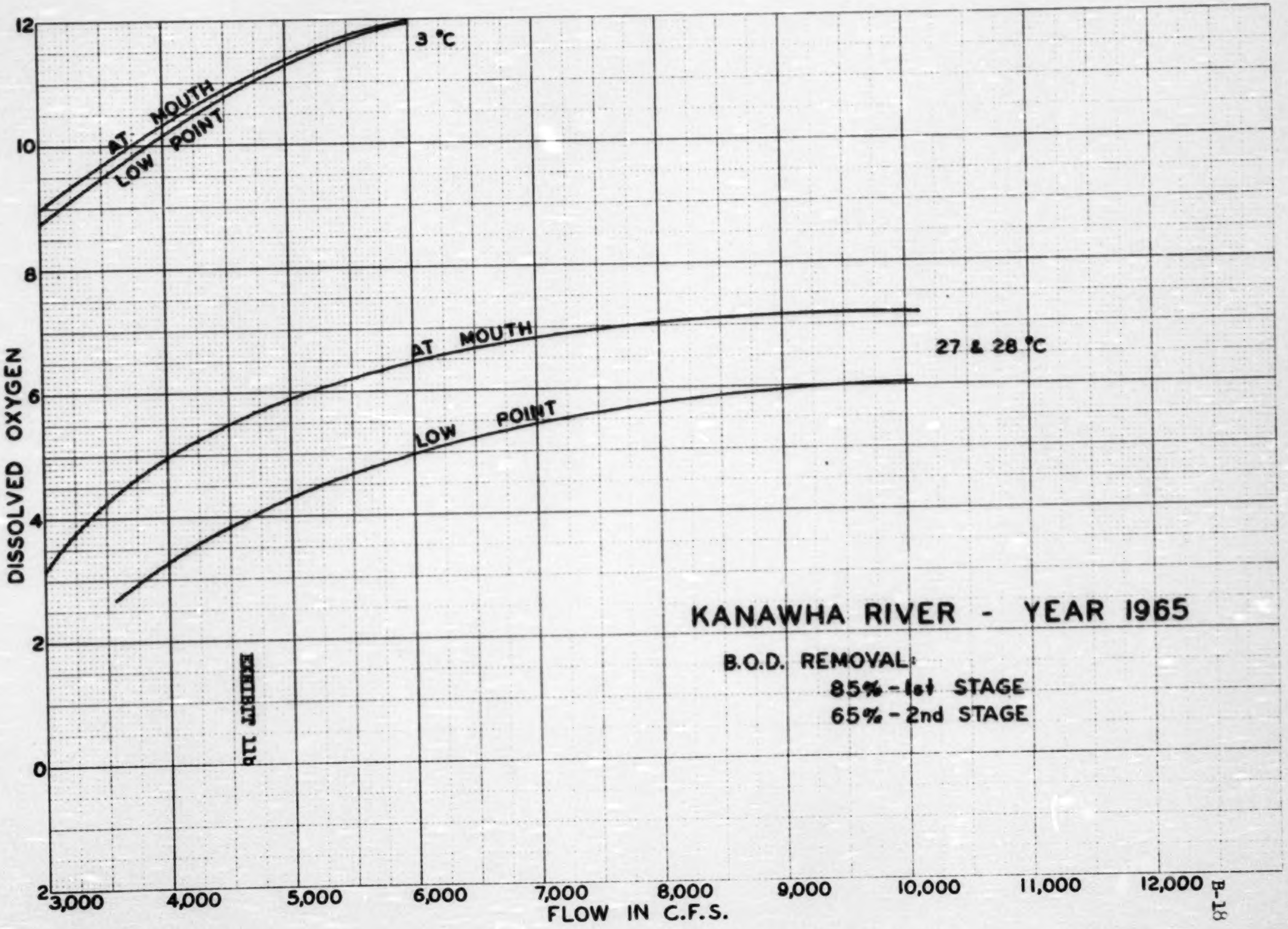
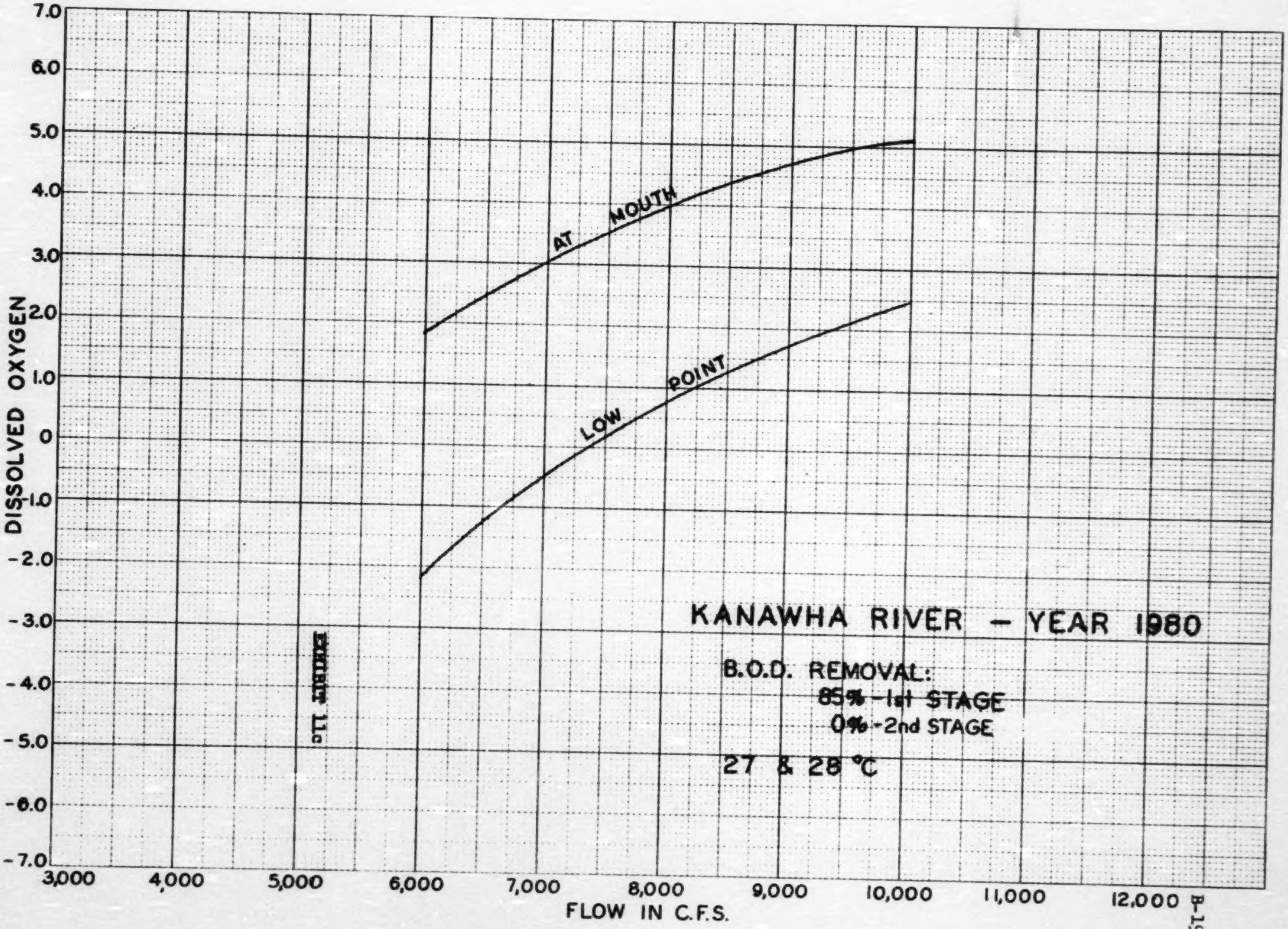
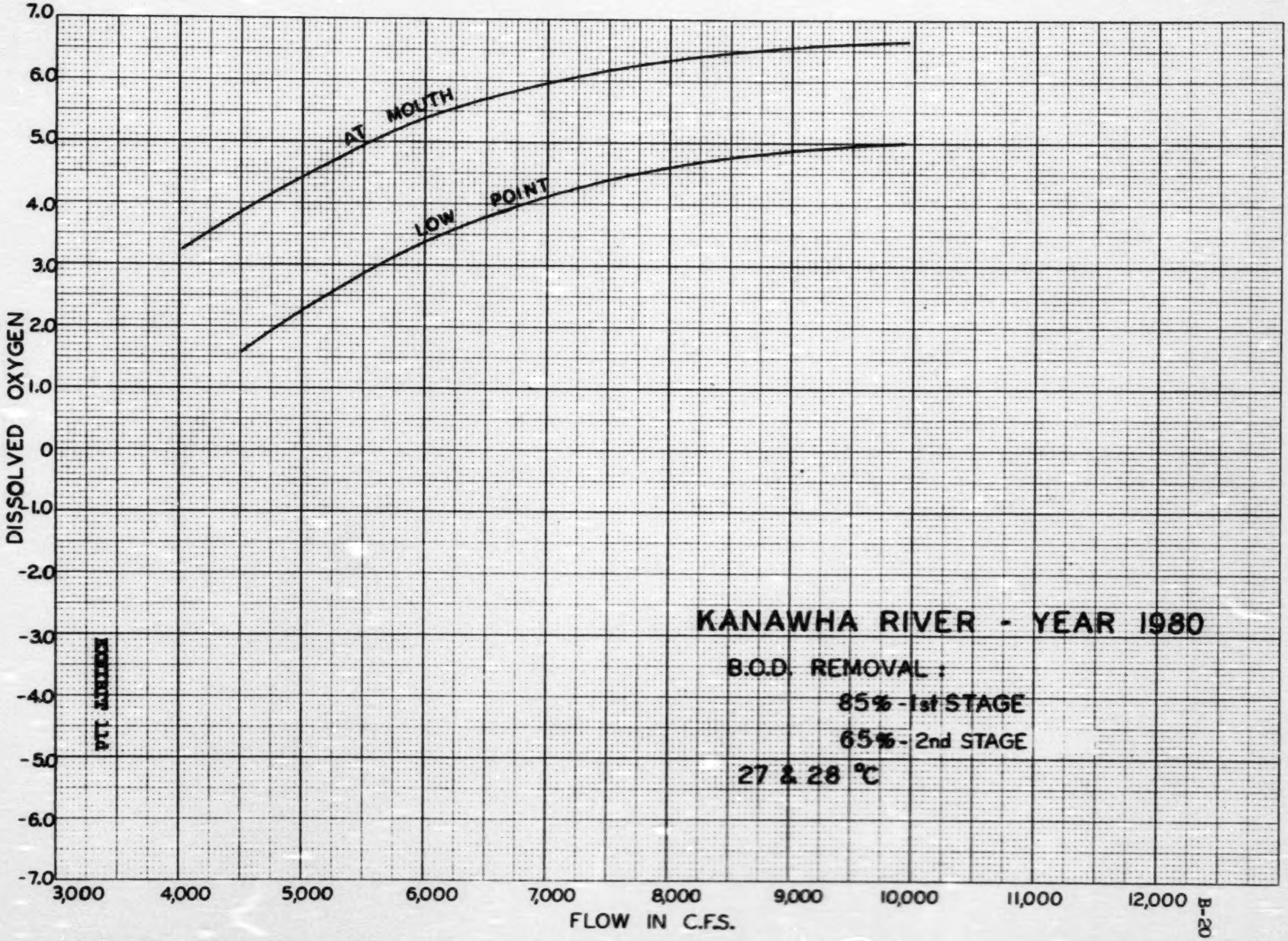

12
10
8
6
4
2
0
2
DISSOLVED OXYGEN
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
FLOW IN C.F.S.
AT MOUTH
LOW POINT
3 °C
AT MOUTH
LOW POINT
27 & 28 °C
KANAWHA RIVER - YEAR 1965
B.O.D. REMOVAL:
85% - 1st STAGE
65% - 2nd STAGE

EXHIBIT 11c


KANAWHA RIVER – YEAR 1980
B.O.D. REMOVAL:
85% - 1st STAGE
0% - 2nd STAGE
27 & 28 °C
AT MOUTH
LOW POINT
DISSOLVED OXYGEN
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
FLOW IN C.F.S.
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000

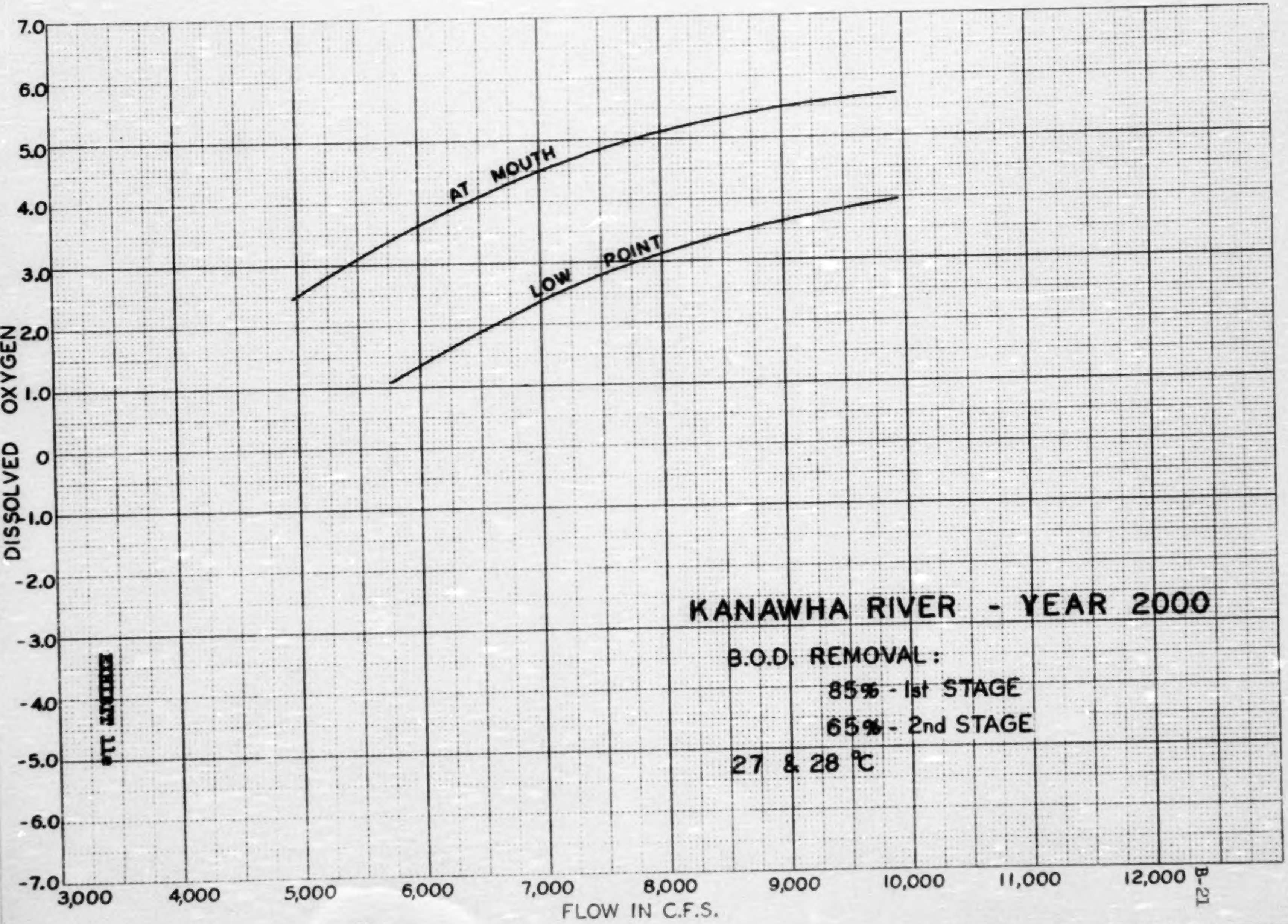


KANAWHA RIVER - YEAR 1980

B.O.D. REMOVAL :
85% - 1st STAGE
65% - 2nd STAGE
27 & 28 °C

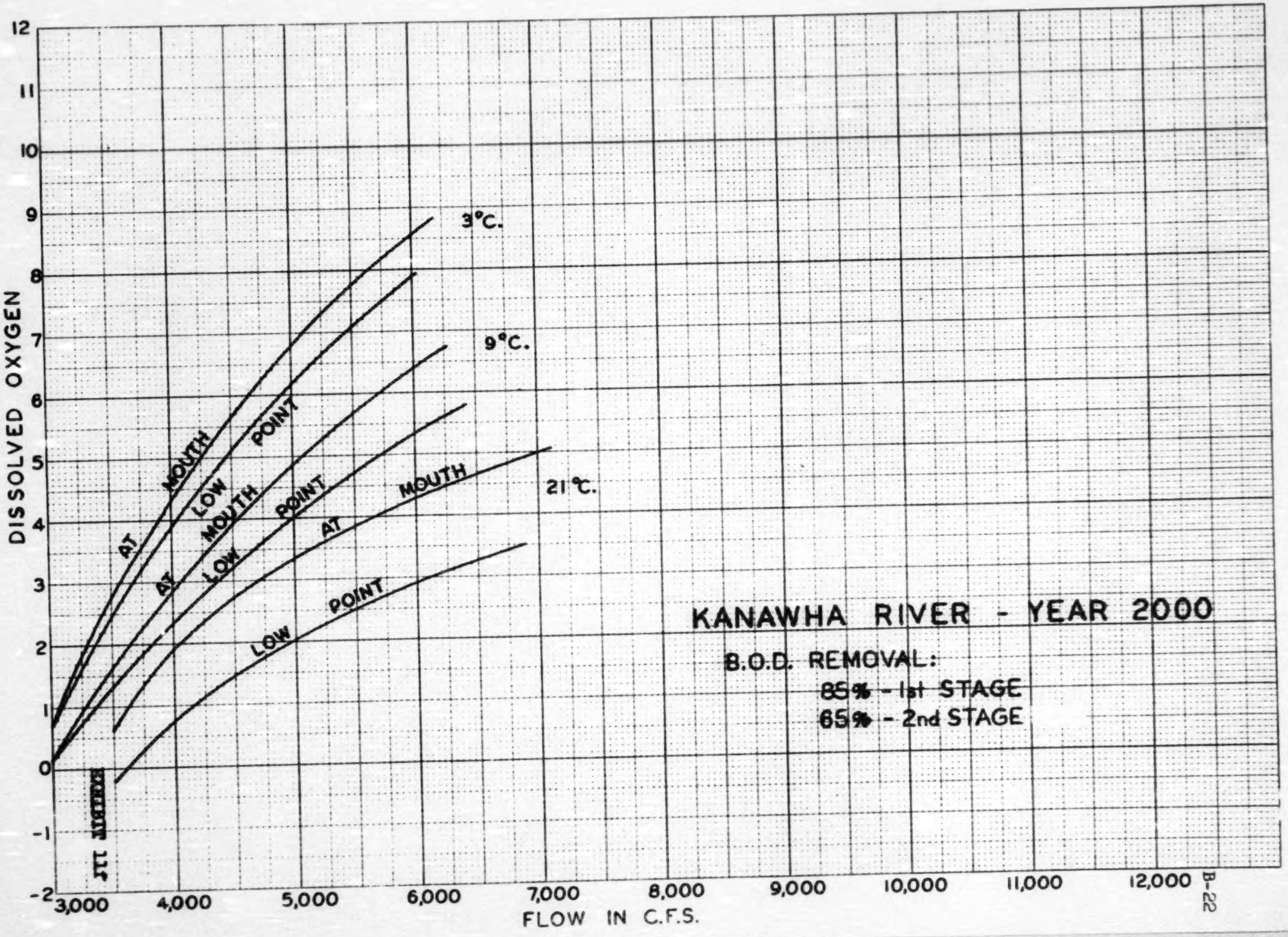
EXHIBIT 11d

EXHIBIT 11e



KANAWHA RIVER - YEAR 2000

B.O.D. REMOVAL:
85% - 1st STAGE
65% - 2nd STAGE
27 & 28 °C



KANAWHA RIVER - YEAR 2000

B.O.D. REMOVAL:
85% - 1st STAGE
65% - 2nd STAGE

EXHIBIT 11f

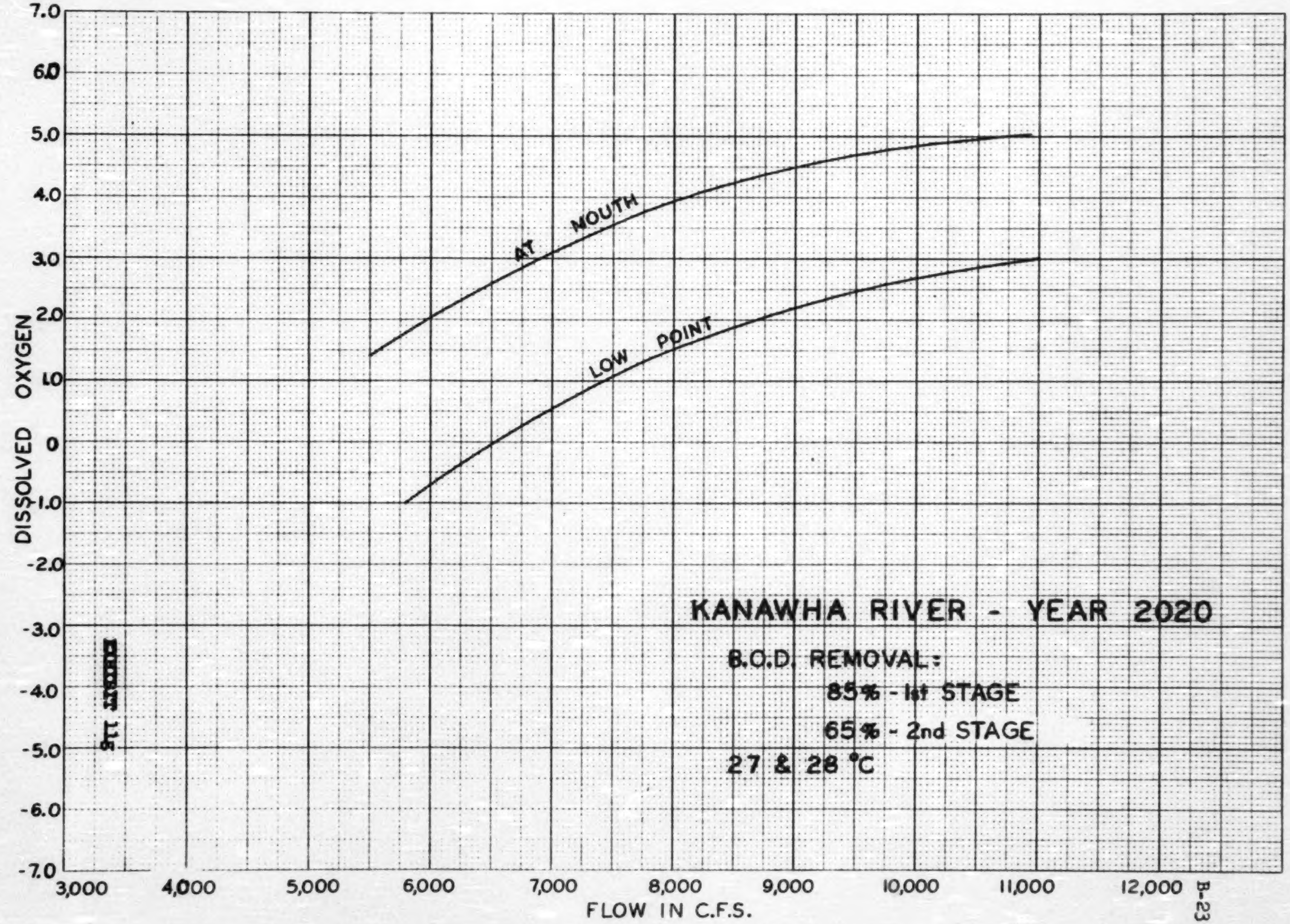

KANAWHA RIVER - YEAR 2020
B.O.D. REMOVAL:
85% - 1st STAGE
65% - 2nd STAGE
27 & 28 °C
AT MOUTH
LOW POINT
DISSOLVED OXYGEN
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
FLOW IN C.F.S.
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000

EXHIBIT 11g

EXHIBIT 12

Streamflow and Storage Required for Water Quality Control Purposes in the Lower Kanawha River to Maintain a Minimum DO of 3 mg/1 and also to Maintain a Minimum of 5 mg/1 at the Mouth
Total Streamflow Required in cfs

	YEAR 1965		YEAR 1980	YEAR 2000	YEAR 2020
TREATMENT	*85% - 1st Stage 0% - 2nd Stage	**85% - 1st Stage 65% - 2nd Stage	**85% - 1st Stage 65% - 2nd Stage	**85% - 1st Stage 65% - 2nd Stage	**85% - 1st Stage 65% - 2nd Stage
MONTH					
January	3,200	1,000	2,900	4,200	5,000
February	3,370	1,200	3,110	4,350	5,700
March	4,225	1,700	3,580	5,100	6,200
April	5,305	2,600	4,290	6,050	7,000
May	6,300	3,200	4,940	6,920	8,500
June	6,910	3,800	5,340	7,460	9,400
July	7,235	4,000	5,560	7,740	10,000
August	7,300	4,000	5,600	7,800	10,600
September	7,170	3,900	5,520	7,690	9,600
October	6,455	3,500	5,050	7,060	8,000
November	5,125	2,700	4,170	5,890	6,500
December	3,710	1,500	3,240	4,650	6,000
Total Draft-on-Storage * Acre-Feet**	1,170,000	250,000	650,000	1,400,000	2,100,000

*Based on adequate treatment of organic wastes discharged to the stream, i.e., 85 percent removal of first stage BOD and 0 percent removal of second stage BOD.

**Based on adequate treatment of organic wastes discharged to the stream, i.e., 85 percent removal of first stage BOD and 65 percent removal of second stage BOD.

***This is the additional quantity needed below Charleston and does not include storage and transmission losses. Based on flows for the period 1939-1963 as adjusted for storage.

EXHIBIT 13

Streamflow and Storage Required for Water Quality Control Purposes in the Lower Kanawha River to Maintain a Minimum DO of 4 mg/1 and also to Maintain a Minimum of 5.5 mg/1 at the Mouth

	YEAR 1965	YEAR 1980	YEAR 2000	YEAR 2020
MONTH	Total Flow Required* cfs	Total Flow Required* cfs	Total Flow Required* cfs	Total Flow Required* cfs
January	1,000	2,900	4,200	5,500
February	1,200	3,100	4,350	5,900
March	1,800	3,800	5,100	7,300
April	2,700	4,600	6,300	9,600
May	3,600	5,700	7,700	11,700
June	4,200	6,500	9,200	13,200
July	4,600	6,800	10,000	14,100
August	4,700	6,900	10,200	14,500
September	4,600	6,700	9,800	14,100
October	4,100	6,000	8,100	12,800
November	3,000	4,800	6,000	10,400
December	1,500	3,400	4,700	6,900
Annual Draft-on Storage** Acre Feet	352,200	1,020,000	1,949,000	3,551,000

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*Based on adequate treatment of organic wastes discharged to the stream, i.e., 85 percent removal of 1st stage BOD and 65 percent removal of 2nd stage BOD.

** This is the quantity needed below Charleston and does not include storage and transmission losses. Based on flows for the period 1939-1963 as adjusted for storage.

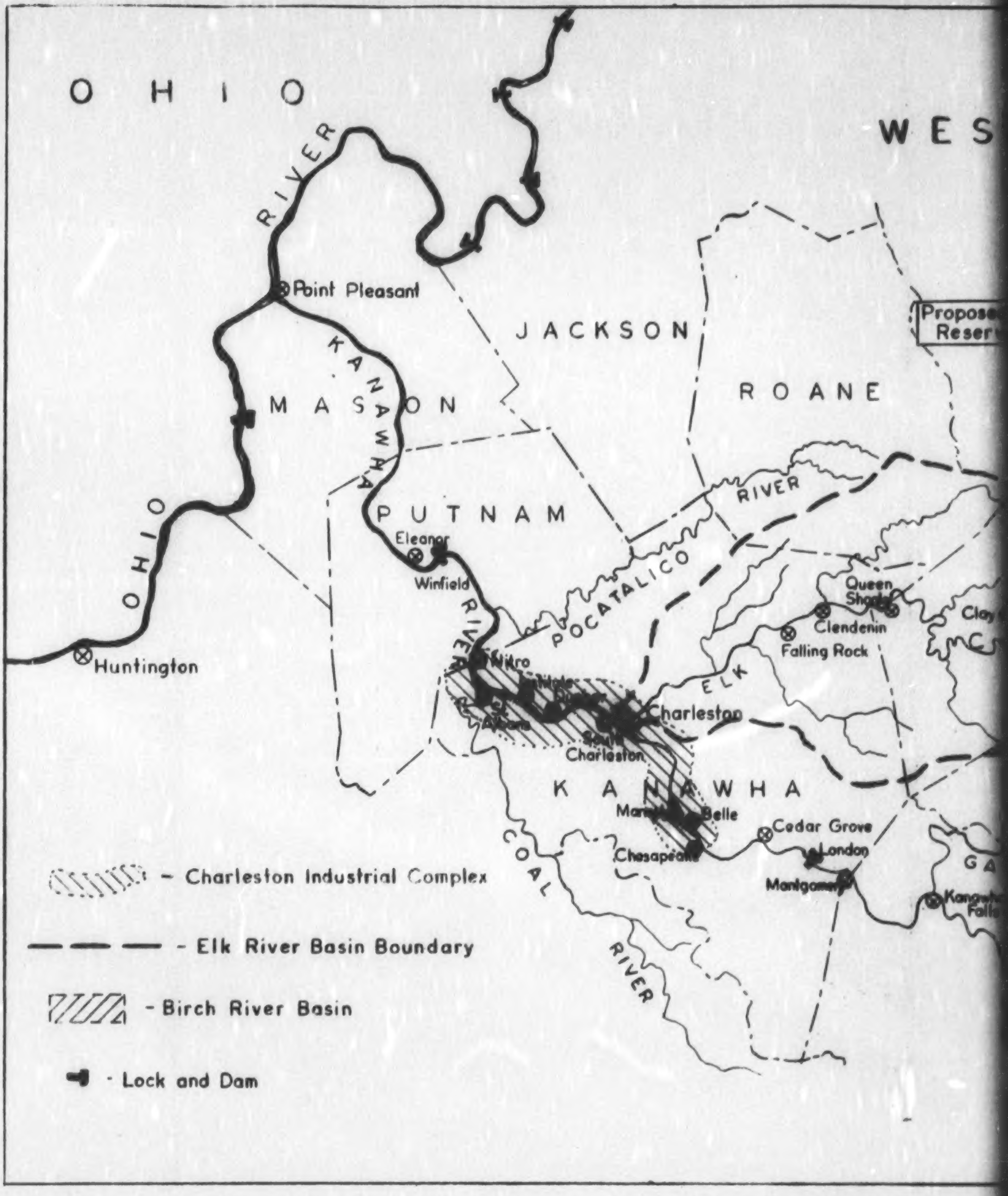
EXHIBIT 14

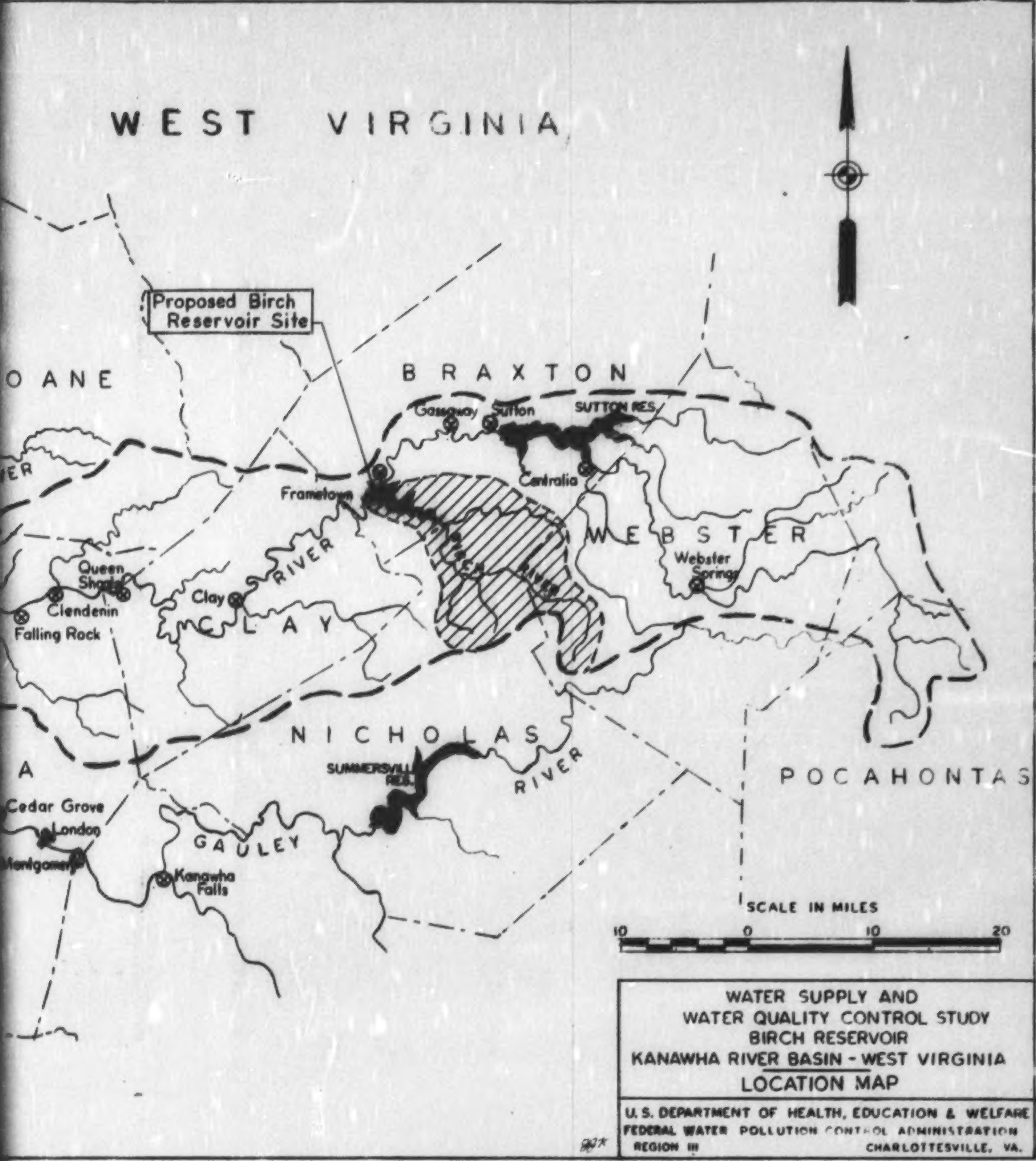
Streamflow and Storage Required for Water Quality Control Purposes in the Lower Kanawha River to Maintain a Minimum DO of 5 mg/l and also to Maintain a Minimum of 6 mg/l at the Mouth

MONTH	YEAR 1965 Total Flow Required* cfs	YEAR 1980 Total Flow Required* cfs	YEAR 2000 Total Flow Required* cfs	YEAR 2020 Total Flow Required* cfs
January	1,600	3,500	4,900	6,100
February	1,800	4,200	5,400	6,900
March	2,700	5,200	6,700	8,800
April	3,800	6,400	9,000	12,000
May	4,800	7,900	11,400	14,300
June	5,600	9,000	13,300	16,100
July	6,000	9,800	14,700	17,500
August	6,200	10,000	15,000	18,000
September	6,100	9,800	14,600	17,500
October	5,700	8,900	13,300	16,000
November	4,300	7,100	10,200	13,200
December	2,500	4,800	6,200	8,300
Annual Draft-on Storage** Acre Feet	807,000	2,033,000	3,651,000	4,913,000

*Based on adequate treatment of organic wastes discharged to the stream, i.e., 65 percent removal of 1st stage BOD and 65 percent removal of 2nd stage BOD.

**This is the quantity needed below Charleston and does not include storage and transmission losses. Based on flows for the period 1939-1963 as adjusted for storage.


OHIO
WES
OHIO RIVER
Point Pleasant
JACKSON
ROANE
Propose
Reser
MASON
KANAWHA RIVER
PUTNAM
Eleanor
Winfield
OHIO
Huntington
POCATALICO RIVER
Queen Shoals
Clendenin
Falling Rock
Clay
ELK
Nitro
St. Albans
Charleston
South Charleston
KANAWHA
Marmet
Belle
Cedar Grove
London
Montgomery
Chesapeake
COAL RIVER
GA
Kanawha Falls
- Charleston Industrial Complex
- Elk River Basin Boundary
- Birch River Basin
- Lock and Dam


WEST VIRGINIA
Proposed Birch Reservoir Site
OANE
BRAXTON
Gassaway
Sutton
SUTTON RES.
Centralia
Frametown
WEBSTER
Webster Springs
BIRCH RIVER
Queen Shoals
Clendenin
Falling Rock
Clay
CLAY
RIVER
ER
NICHOLAS
SUMMERSVILLE RES.
RIVER
POCAHONTAS
A
Cedar Grove
London
Montgomery
GAULEY
Kanawha Falls
SCALE IN MILES
10
0
10
20

WATER SUPPLY AND
WATER QUALITY CONTROL STUDY
BIRCH RESERVOIR
KANAWHA RIVER BASIN - WEST VIRGINIA
LOCATION MAP

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
REGION III CHARLOTTESVILLE, VA.

FIGURE IV